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TWO NEW SPECIES OF GENUS *CTENUS* WALCKENAER (ARANEAE : CTENIDAE) FROM COASTAL ANDHRA PRADESH, INDIA

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Two new species of spiders of genus *Ctenus* Walck. (family : Ctenidae) viz., *Ctenus tuniensis* and *C. narashinhai* are described in detail and illustrated from East Godavari and Visakhapatnam Districts of Coastal Andhra Pradesh, India.

(Key words : two new spiders, *Ctenus tuniensis, C. narashinhai,* East Godavari, Visakhapatnam, Andhra Pradesh, India)

INTRODUCTION

The spiders of this very small family Ctenidae are separated from very close members of Clubionidae and Lycosidae because of the peculiar arrangement of their eyes which are forming three rows. Though the family is poorly reported from India, the genus *Ctenus* Walckenaer was reportedfrom scattered places from North-East to South India by various workers, such as Simon (1897, 1904), F. O. P. Cambridge (1897, 1902), Gravely (1931) and Tikader (1973, 1976). Recently Tikader & Malhotra (1981) revised Indian species of this genus and described one new species and redescribed eight species from India. They have included two species from Sri Lanka, expecting that they may be occurring in India. While examining the spider collections made from Coastal Andhra Pradesh, we came across two new species of this genus which are described and illustrated here, making the total number of species to eleven. This is the only genus of the family represented from India.

The type specimens will in due course be deposited in the National Collections of Zoological Survey of India, Calcutta.

Ctenus tuniensis sp. nov. (Fig. 1, a–e)

General: Cephalothorax and legs reddish brown, abdomen brownish green. Total length 8.63 mm. Carapace 3.09 mm long, 2.36 mm wide; abdomen 5.54 mm long, 2.72 mm wide.

Cephalothorax: Longer than wide, narrowing anteriorly, clothed with pubescence and some spine like hairs. Posterior middle provided with a black conspicuous fovea. A light reddish brown longitudinal band extending from ocular area to the base of cephalothorax is present. Thin brown streaks are radiating from near the fovea to all sides except the anterior side. Both rows of eyes recurved but anterior row strongly recurved, so that the anterior laterals come in the line of posterior medians, thus forming three

rows of eyes. Except anterior laterals all eyes are encircled with black patches. Anterior laterals being situated in front of the posterior laterals. Ocular guad slightly longer than wide, slightly wider behind than in front as in Fig. 1, a. Sternum nearly oval, slightly narrow behind, brownish yellow, clothed with spine–like hairs. Labium as long as wide, distal end pale with few hairs. Maxillae yellowish in colour and provided with scopulae at the ends. Sternum, labium and maxillae as in Fig. 1, b. Chelicerae moderately stout, retromargin provided with five unequal teeth and promargin with three teeth as in Fig. 1, e. Legs thin and long. Tibiae with five and metatarsi with three pairs of ventral spines on legs I and II. Leg formula 4 1 2 3. Male unknown.

Abdomen: Elongate, longer than wide, brownish green, clothed with pubescence; mid–dorsally provided with a white longitudinal band extending from the whole length with seven pairs of light yellow spots on its margin as in Fig. 1, a. Ventral side lighter than the dorsal, clothed with pubescence. Epigyne and internal genitalia as in Fig. 1, c and d.

Holotype: One ♀ in spirit.

Type-locality: Tuni, Dist. East Godavari, 11.ix.1985. Coll. T. S. Reddy.

Diagnosis: This species resembles *Ctenus smythiesi* Simon but it is separated as follows: (i) The cephalothorax with a mid–dorsal light reddish brown longitudinal band extending from ocular area to the base of cephalothorax but in *C. smythiesi* cephalothorax provided with a mid–dorsal longitudinal pale patch. (ii) Chelicerae stout, inner and outer margins of fang furrow with five and three unequal teeth resp. but in *C. smythiesi*

chelicerae moderately stout and inner margin of fang furrow with four unequal teeth. (iii) Abdomen with a white longitudinal band with slight undulating margin but in *C. smythiesi* the margin of white longitudinal patch is more deep forming the shelves like deep grooves. (iv) Epigyne and internal genitalia are also structurally different.

Ctenus narashinhai sp. nov. (Fig. 2, a—e)

General: Cephalothorax and legs reddish brown, abdomen olive green. Total length 19.41 mm. Carapace 8.75 mm long, 6.66 mm wide; abdomen 10.33 mm long, 7.50 mm wide.

Cephalothorax: Longer than wide, narrowing anteriorly, covered with pubescence and some spine like hairs. A prominent fovea present on thorax and brown streaks radiate from it to the sides and posteriorly. Both rows of eyes recurved but anterior row strongly recurved, so that the anterior laterals come in the line of posterior medians, thus forming three rows. Anterior medians and posterior row of eyes are encircled with black patches. Posterior medians are bigger than all other eyes. Ocular quad longer than wide, slightly wider behind than in front as in Fig. 2, a. Sternum heart shaped, pointed behind, reddish brown, clothed with hairs, margin darker. Labium and maxillae longer than wide, distal ends pale in colour with scopulae. Sternum, labium and maxillae as in Fig. 2, b. Chelicerae strong with chocolate brown hairs on the front side; retromargin with four and promargin with three teeth. Legs stout with spines and hairs. Tibiae I and II with five, III and IV with three pairs of stout ventral spines. Metatarsus of all legs with three pairs of stout ventral spines. Leg formula 4 1 2 3. Male unknown.
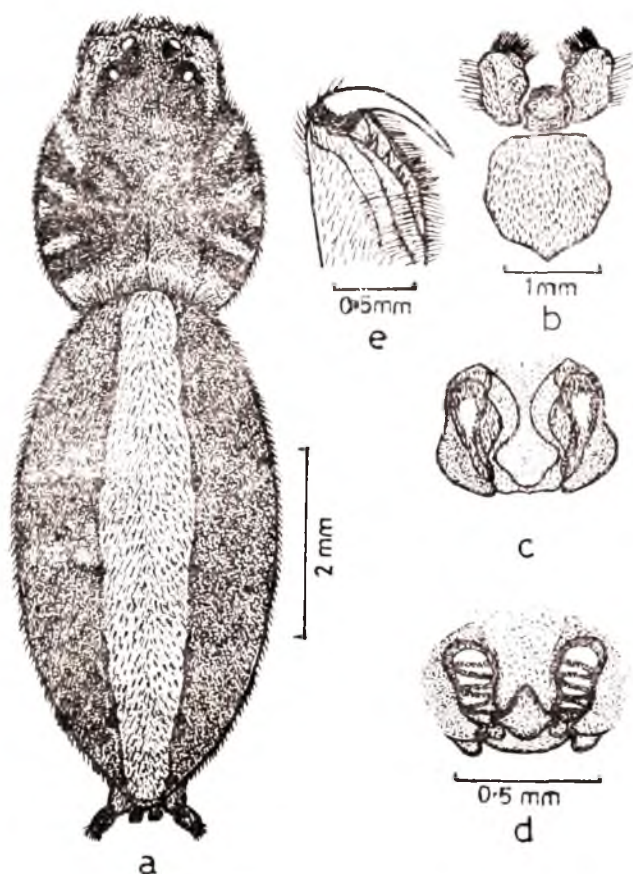
Fig. 1. *Ctenus tuniensis* sp. nov; a. Dorsal view of female, legs omitted;
b. Sternum, labium and maxillae; c. Epigyne; d. Internal genitalia;
e. Right chelicera, ventral view.

Abdomen: Oval, longer than wide, pointed behind, clothed with pubescence, anteriorly provided with pale longitudinal patch and dorsum with two pairs of sigillae as in Fig. 2, a. Ventral side brown with two parallel rows of white spots extending from epigastric furrow up to the base of spinnerets. Epigyne and internal genitalia as in Fig. 2, c and d

Holotype : One ♀ in spirit.

Type-locality: Simhachalam, Dist. Visakhapatnam, 7.x.1986. Coll. T. S. Reddy.

Diagnosis: This species resembles *Ctenus sikkimensis* Gravely but it is separated as follows : (i) Chelicerae provided with four teeth on retromargin and three teeth on promargin of fang furrow but in *C. sikktmensis* chelicerae provided with four teeth on retromargin of fang furrow. (ii) Arrangement of white coloured patches on cephalothorax and abdomen are different. (iii) Abdomen is oblong, widest in the middle but in *C. sikkimensis* abdomen is rather rectangular in shape. (iv) Structure of epigyne and itnernal genitalia are also different.
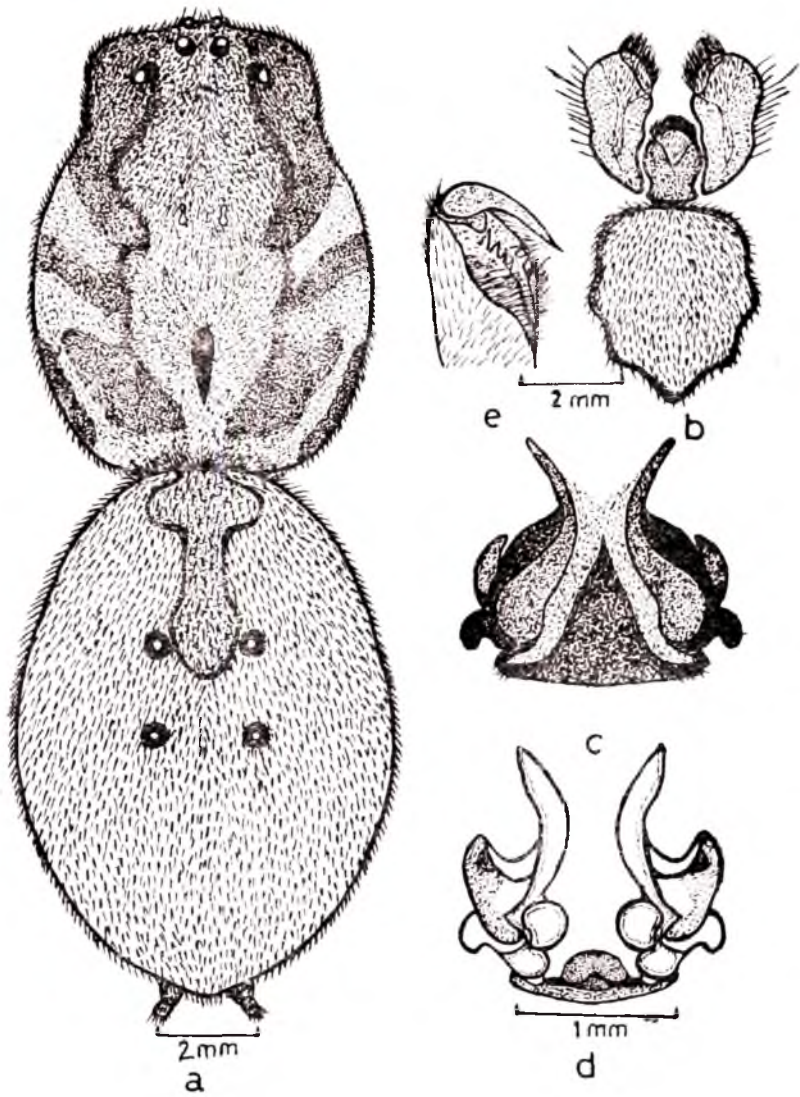
Fig. 2. *Ctenus narashinhai* sp. nov; a. Dorsal view of female, legs omitted;
b. Sternum, labium and maxillae; c. Epigyne; d. Internal genitalia;
e. Right chelicera, ventral view.

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PHYSICAL PROCESSES AND MECHANISM OF SOUND PRODUCTION IN FIELD CRICKET GRYLLUS BIMACULATUS DE GEER

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The paper describes the acoustic apparatus of field cricket *Gryllus bimaculatus*. A model is proposed for the mechanism of sound production. Physical and acoustic apparatus are reported. Mutilation expetiments on the elytra of the insect were performed to study the relative contribution of the components of the acoustic apparatus. Different physical processes involved in the sound production such as signal generation, amplification, frequency modulation (F M) and amplitude modulation (A M) are discussed. The quality of the sound is analysed by the sonagraphic technique. It consists of fundamental (5 KHz) and two overtones (10,5 & 16 KHz), the former being prominent.

(Key words : G. bimaculatus, file-scraper system, frequency generator, amplifier, frequency modulator, amplitude modulator, frictional mechanism, resonance, elytral vibration)

INTRODUCTION

A search of literature reveals that the reports on the song patterns of different species of crickets are available from a long time. But only in the last two decades this subject received the attention of researchers thoroughly. BROOKS (1882) discovered the variation in the chirping rate with temperature. DOLBEAR (1897) and BASSEY & BESSEY (1898) proposed emperical formulae relating chirping rate and temperature. The first physical study of the song of crickets were carried out by KREIDL & REGEN (1905). They determined the frequency spectrum of the songs of field crickets, using strobscope and gramaphone. LUTZ (1924) was the first to introduce electrostatic technique for the same. PIERCE (1948) established the field of research in the analysis and mechanism of sound emission. He studied the photographs of stridulating *Acheta*

pennsylvanicus frame by frame and proposed that each oscillation corresponds to the impact of plectrum against a tooth of par stridens. HUBER (1963) and HORMANN-HECK (1957) investigated the physiological and genetic basis for aggressive and sexual behaviour in European cricket. ALEXANDER (1957, 1961) did regorous work on song relationship of different species and their behaviour. EWING & HOYLE (1965) and BENTLY & KUTSCH (1966) studied the neuromuscular mechanism of stridulation in crickets.

WIESE KONRAD (1981) studied the influence of vibration on the cricket, *Gryllus bimaculatus* hearing. RAINLENDER *et al.* (1981) found in *Gryllus bimaculatus.* that the accuracy of female orientation is due to the difference in the level of the activity of symmetrical pair of low frequency neurons. PASQUINELLI & BUSNEL (1955) proposed that the impact

of each lamella against scraper induces a single oscillation. Hence the number of elementary waves in chirps (wave packet) corresponds to the number of lamellae. But LOTTERMOSSER (1952) reported that elytra of field crickets produce a particular range of frequency (4–5 KHz), and it has nothing to do with the velocity of the file, that rubs against the scraper and number of lamellae present in the file.

The review article of DUMORTIER (1963) covered a wide ground. According to DUMORTIER, the explanation of the phenomenon given by PIERCE (1948) seems to be a probable one and on this basis he proposed two hypotheses :

1. Either the tooth strike rate (TSR) corresponds to the natural frequency of all or part of the elytron.

2. Or, on the other hand, the elytron works in forced vibrations at frequencies different from its own.

DUMORTIER, by cutting the elytra in such a way as to leave only the plectrum and par stridens, found that the intensity was effected considerably but not the frequency. This leads to the conclusion that plectrum–par stridens system should act as acoustic signal generator and the rest of the elytra is playing the role of an acoustic coupler enabling the transmission of feeble acoustic energy to air. He concluded that the explanations given for the mechanism of sound production were hypothetical.

SISMONDO (1979) discussed the stridulation in *Oecanthus* in relation to theories concerned with the mechanism of tegminal resonance and reported the concept of resonator with continuously variable tuning. Recently the authors (1984) studied the acoustic charactertics and behaviour of the cricket *Grillodes sigillatus*. ADEEL AHMAD *et al.* (1986) reported that the whole elytron of the field cricket *Gryllus bimaculatus* is not effective for the vibrations but only a part of it, the rectangular portion bounded by three fixed sides (cubital vein, rib and bent elytral tip) is effective. Further, they derived an expression for the frequency of elytral vibrations, considering two-dimensional wave equation and applying suitable boundary conditions for the rectangular membrane.

Thus the perusal of literature reveals that experimental data is too meager to arrive at any conclusion to propose an appropriate model for the production of sound in crickets. Hence it is still a moot point to decide what hypothesis should be accepted. In view of this, the authors have carried out investigations on the physical processes of sound emission and mechanism of sound production of field cricket *Gryllus bimaculatus*.

MATERIAL AND METHODS

The field crickets *Gryllus bimaculatus* (Orthoptera : Gryllidae) are available in Hyderabad City. They were collected from around street lights, since they normally produce sound during night time. The insects can fly and also have long elytra. The elytra of male insects are modified to form the sound producing apparatus. The male insects alone can produce sound.

Acoustic apparatus in field crickets consists of two components–one is the file-scraper system and the second is the elytron tiself. The first component of the acoustic apparatus, called signal generator is situated in the anterior portion of the elytron (Fig. 1).

Experimental: With a view to understand the mechanism of acoustic emission, mutilation experiments were performed on the elytra in three steps. At the first step of the investigation, both the elytra were mutilated simultaneously in steps along the transverse direction to their axis till the scraper-file
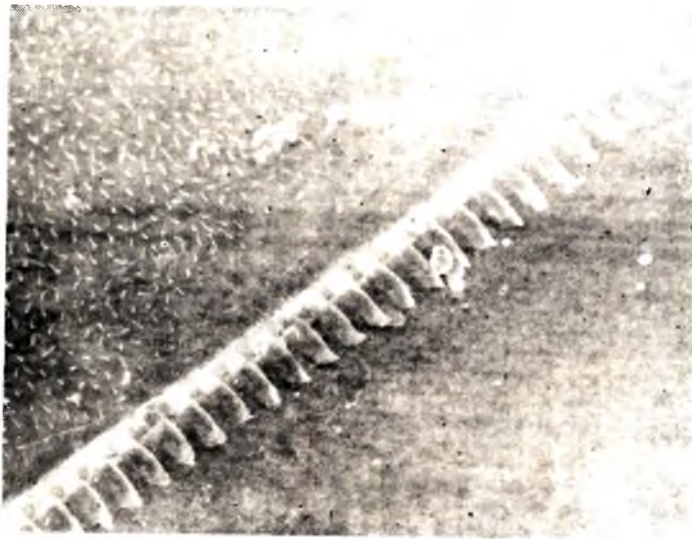
Fig. 1 (a) The structure of the file. Scan micrograph magnification × 60

Fig. 1 (b) The structure of the scraper. Scan micrograph magnification × 60

system approached. In the second stage of the study elytra were mutilated in steps along the longitudinal direction. At the third step, one of the elytra was mutilated transversely, keeping the other elytron intact. In all the above stages insects were allowed to move freely and stridulate. The sound was recorded on a magnetic tape record (Akai 1120 L) using a condenser microphone (Sony ECM— 19 B). The recorded signals were fed to a double beam oscilloscoe (Philips P M 3230) and ocillograms were taken. The intensity of the sound was determined using a millivoltmeter (Simpson model 717-1) (PURANIK & ADEEL AHMAD, 1976). The quality of the sound was analysed using a sonagraph (Key Elementrics N. J.). The physical parameters of the acoustic apparatus were measured from Scan electron micrographs.

To examine the role played by the acoustic surface (elytron) in the frequency spectrum and intensity of the sound produced, the elytron was removed from the insect and were mutilated transversely into a number of strips, the width of each strip being 0.2 cm. The surface area of each strip enlarged under the onlarger (KB-model 69 A) was measured using a planimeter. Whereas the mass of each strip was determined using an analytical balance of least count 0.02 mg. Knowing the area and mass of the strips, the surface density (mass/area) of the elytron along its major axis was computed. A graph was plotted between surface density of a strip and the strip

distance from the elytral joint. The above was repeated for the elytron of female insect, for comparison. For the measurements of teeth-spacing, the whole file was scanned under a comparator of least count 0.0001 cm. (PURANIK et al., 1981). The frequency of waves, wave-packets and sequence of wave packets were determined by oscilloscopic technique as suggested by the authors earlier (ADEEL AHMAD & SIDDIQUI, 1984).

RESULTS AND DISCUSSION

To propose an appropriate model for the mechanism of sound production, the physical and acoustic parameters of the acoustic apparatus and different physical processes involved in the acoustic emission of G. bimaculatus were critically studied.

Physical parameters of acoustic apparatus: Length (L) of the file, spacing (s) and number (N) of teeth, length (l), breadth (b) and mass (m) of the acoustic surface are the physical paramters of the acoustic apparatus and the data of which for six specimens is shown in Table 1. All these parameters remain to be constant at different states of acoustic emission such as courtship, calling and aggression. From the table it is obvious

TABLE 1. Physical perameters of acoustic apparatus of G. bimaculatus.

Body mass M (gm)	elytral mass m (gm)	elytral length l (cm)	elytral breadth b (cm)	file length L (cm)	No. of teeth, N	Teeth spacing	
						S max (X10⁻3 cm)	S min.
1.369	0.0085	2.25	0.75	0.5120	159	4.7	2.4
0.884	0.005	1.85	0.70	0.5181	154	4.5	2.5
1.073	0.0068	1.9	0.70	0.4750	150	4.4	2.3
1.280	0.0076	2.0	0.75	0.4548	154	4.7	2.5
1.073	0.0065	1.8	0.70	0.5121	156	4.5	2.3
1.064	0.0062	1.8	0.70	0.5130	160	4.3	2.2

TABLE 2. Acoustic parameters of *G. bimaculatus*.

| Body mass (g) | wave packets (pulses) | | | | | | | | | | | Sequence (chirp) | | frequency of | | |
| | duration (msec) | | | | latent time (msec) | | | amplitude | | | | dura-tion (msec) | latent time (msec) | sequ-ence (Hz) | wave pkts (Hz) | wave (Hz) |
	1	2	3	4	1	2	3	1	2	3	4					
1.369	15.1	16.1	14.2	12.2	8.3	8.3	8.8	4.8	4.7	4.4	2.5	82.5	88.9	6	42	4900
0.884	19.2	18.5	18.5	18.5	13.1	12.31	11.5	3.0	2.9	2.8	2.4	111.6	110.3	4	32	5200
1.073	22.6	21.8	22.2	21.8	6.7	6.7	6.7	4.8	5.0	4.6	4.0	108.5	112.4	5	34	5500
1.280	22.4	22.4	21.6	22.8	6.5	6.7	8.2	4.8	4.6	4.6	4.6	110.6	114.7	4	34	5300
1.064	20.7	20.1	20.1	20.0	6.2	6.4	6.7	3.9	3.8	3.8	3.2	100.2	118.6	5	37	5200
1.073	23.1	22.4	22.1	22.0	7.0	7.1	7.1	4.8	4.7	4.2	4.0	110.8	116.1	4	33	5400

that the teeth in a file of different specimens are more or less the same in number and spaced according to Fig. 2. Fig. 3 is the plot between strip distance and surface density of the strip for the elytra of male and female *G. bimaculatus*. Exponential decrease in the surface density with strip distance is evident from the figure. This provides necessary rigidity at the elytral joint and flexibility at the appropriate places along the elytron during the sound production. But the surface density of elytron is relatively high in male than female.

Acoustic parameters of G. bimaculatus: Waves, wave packets and sequence of wave packets (Fig. 4) are considered as acoustic parameters and they are influenced by the physiological conditions of the insect. The insect emits four distinct type of songs viz., calling, aggressive and two types of courtship songs. Each song is composed of a group of wave packets and each wave packet corresponds to a single elytral movement. The song differs only in regard to either the number of wave packets in a sequence or their amplitudes.

Table 2 gives the data on acoustic parameters of calling song for 6 specimens of *G. bimaculatus*. It is evident from the table that the calling song has fundamental frequency in the range 4500 to 5500 Hz. Each sequence consists of four wave packets with increasing amplitude and time period (Fig. 4). Two consecutive sequences are spaced by a sufficient time referred to as 'latent time'. The sequence rate varies from 3 to 5 Hz.

The aggressive song consists of very long sequence containing many wave packets. The number of wave packets in a sequence depends upon the extent of aggression (Fig. 5).

The courtship song is distinguished from the other two patterns by a shortening of the sequence, a decrease in sound intensity and appearance of a new element called 'intersequence' (Fig. 6). It is established that the intersequence of wave packets are produced by an impact of the costal field of the elytra against the body.

Physical processes and mechanism of sound emission: Acoustic signal generation, amplification (intensity), amplitude modulation (AM) and frequency modulation (FM) are the four important physical processes which are discussed to propose a physical model for the mechanism of acoustic emission in *G. bimaculatus*.

The mutilation of one pair of elytra transversely reveals that the frequency of the waves remains constant for different mutilations in steps till the scraper–file system is approached (Fig. 7). But the intensity of the sound decreases with the degree of mutilation (Fig. 8). This indicates that the scraper–file system acts as an acoustic signal generation. As each tooth of the file passes over the scraper, a thrust in one direction is given to the file, and opposite thrust to the scraper. These thrusts are periodic forces with the frequency determined by the number of impacts per second of the file-teeth with the scraper. The periodic forces are fed to the elytron and the effective rectangular portion of the elytron bounded by three fixed sides (cubital vein, rib and bent elytral tip) is vibrating with the frequency of the driving forces (ADEEL AHMAD *et al.*, 1984).

Amplification (Intensity): Four hypotheses are possible for the sound waves. (1) Acoustic apparatus is assumed to
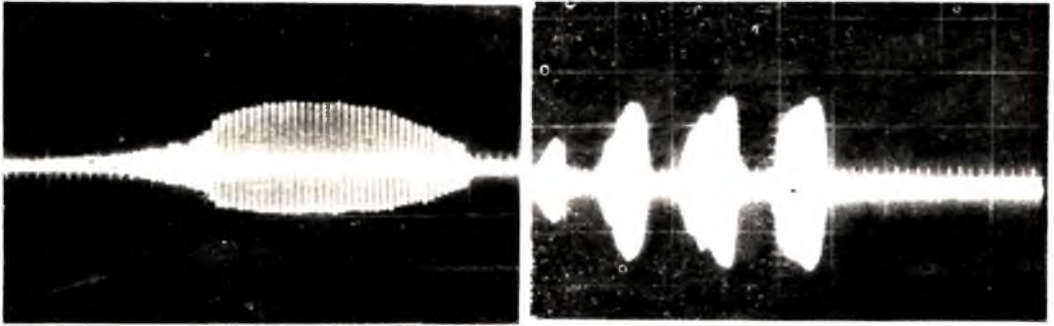
Fig. 4a, b. Typical oscillograms of calling song showing (a, left) waves,
(b, right) wave packets and sequence of wave packets
(a) Time mark: 1 div = 1 msec (b) Time mark: 1 div = 10 msec
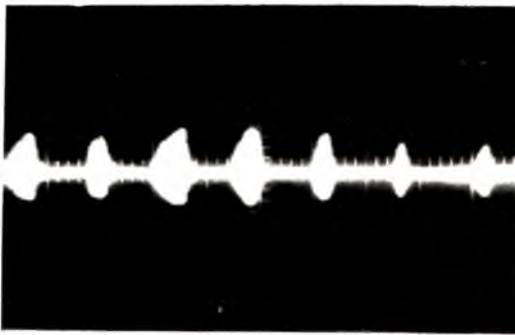
Fig. 5. Typical oscillogram of aggressive
sound. Time mark: 1 div = 10 msec
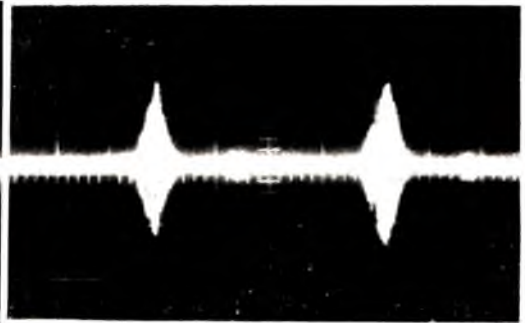
Fig. 6. Typical oscillogram of courtship
sound. Time mark: 1 div = 10 msec

Fig. 7. Typical oscillogram of the sound
when the elytra are mutilated transversely.
Time: 1 div = 10 msec.
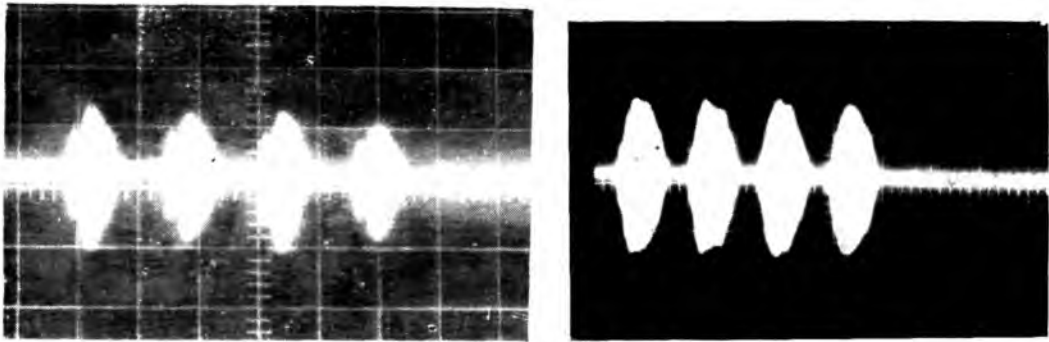
Fig. 9. Typical oscillograms of the sound when one of the elytra is mutilated (a, left) Longitudinally and (b, right) Transversely. Time mark: 1 div = 10 msec

Fig. 10. Sonagram of the calling sound. Time versus frequency. Each band is of 1 KHz.

behave similar to electrodynamic loud-speaker, in which a membrane is submitted to forced vibrations, transmitted by the exiter (moving coil). The membrane has low frequency but can respond to distinctly higher frequencies. The elytron can be compared to membrance and file-scraper system with the moving coil.

(2) The elytron is playing the role as acoustic coupler, transmitting the acoustic energy to the air enclosed by the elevated elytra. If the area of the acoustic surface is large, more acoustic energy will be transmitted and hence the loudness of the sound.

(3) The intensity of the sound waves is due to the resonance of the air column enclosed by the elevated elytra with the frequency of the signal generator.

(4) The elytron is vibrating with the forced oscillations of the file-scraper system and the frequency of which is equal to one of the natural frequencies of the elytron. Hence resonance occurs.
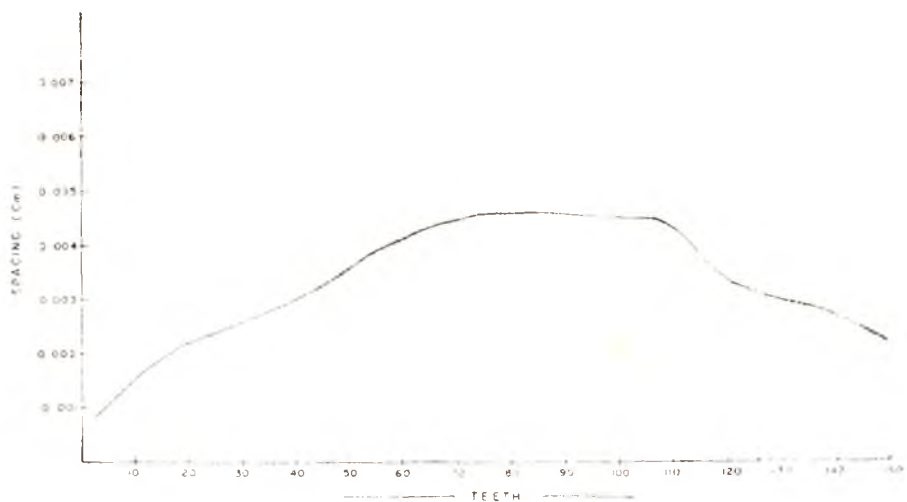
Fig. 2. Least square fit plot of teeth spacing.
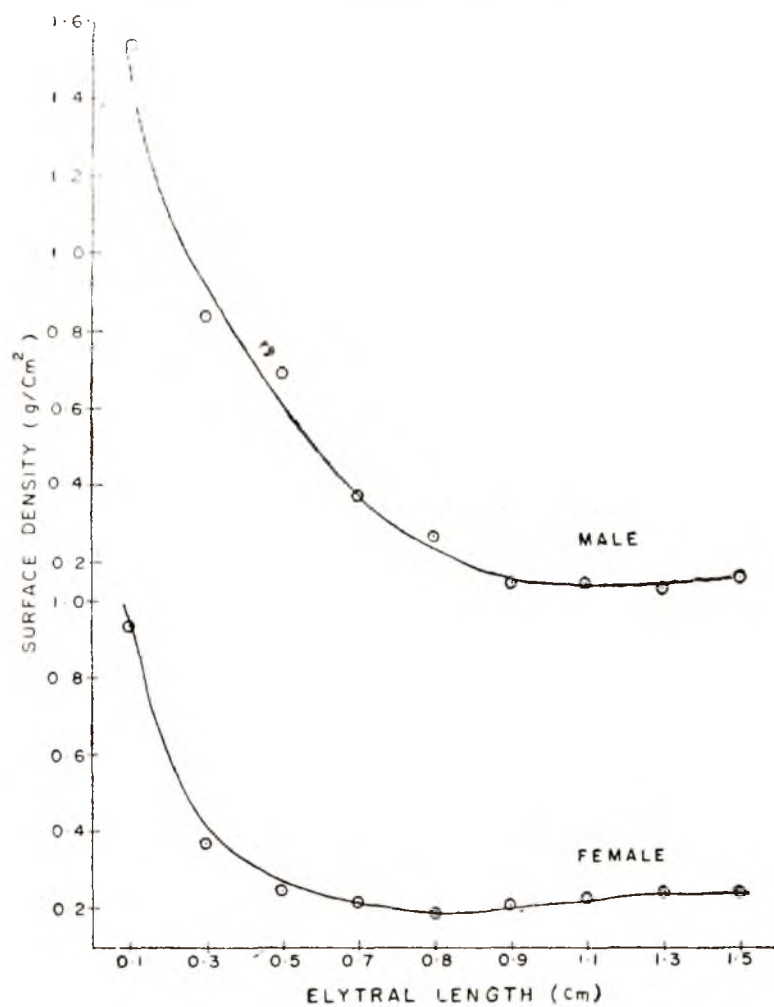
Fig. 3. A plot between strip distance and surface density.
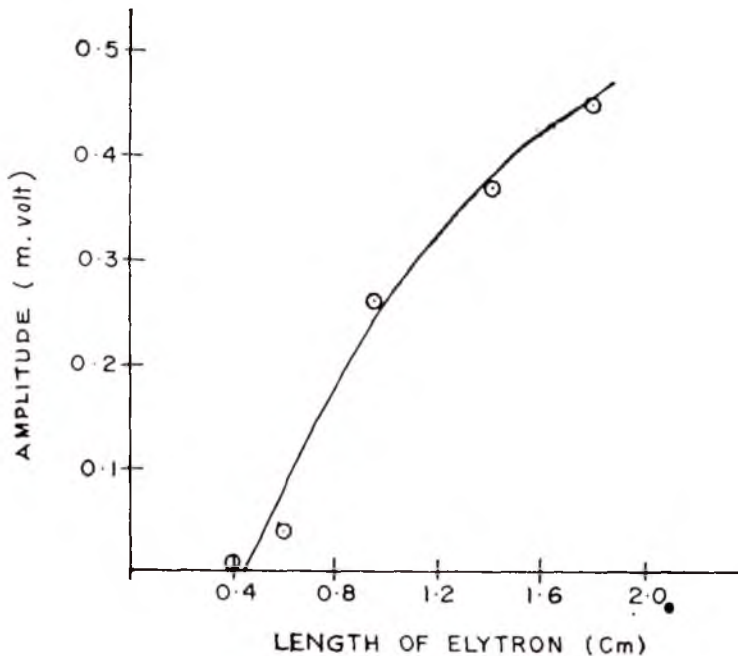
Fig. 8. A plot between length of the elytron and amplitude of sound.

The first hypothesis may be ruled out because of the fact that the elytron cannot have low frequency due to its smaller dimensions. It can not work for all the frequencies of the sound waves, since its responce is selective to a particular frequeney as revealed by the spectroaudiograms of HUBER (1960). The second and third hypotheses have no place if the longitudinal or transverse mutilation of the single elytron is considered. It is observed that the frequency and intensity of the waves are not affected by the mutilation whereas area of the acoustic surface is reduced considerably (Fig 9). The fourth hypothesis with a modification appears to be very close to reality. It may be proposed that the elytron is vibrating with the forced oscillations of file–scraper system (signal generator). The elytron having single natural frequency but not the band of natural frequencies (ADEEL AHMAD *et al*. 1984), resonates with one of the frequencies of the signal generator and hence increase in the intensity of sound.

Frequency modulation (FM) and Amplitude modulation (AM): The stridulatory movement is the result of a co-ordination of several muscles and parts of the body, performed by a nervous process. The most important muscles for the stridulatory movement appear to be abductor muscles. When these muscles contract, elytra are drawn inward and this is the 'closing stridulatory movement'. When they relax, the elevator and promotor muscles are contracted and elytra return to the initial position, which is referred as 'opening stridulatory movement'. When the abductor muscles contract, the scraper gets into contact

with the file and stridulations start. Since muscles behave like a critically damped helical spring, during contraction the velocity causes down slurring (frequency modulation) in the frequency of the signal generator (scraper-file system). From the sonagram (Fig. 10) it is observed that the frequency variation is in the range 4500 to 5500 Hz.

The amplitude modulation (AM) of the signal (wave) is assumed to be based on resonance phenomenon. It is obvious that the forced vibrations of elytra is mainly due to the periodic driving force of the signal generator. Resonance occurs when one of the frequencies of the signal generator is matched with the natural frequency of the acoustic surface (elytron) and hence amplitude of the wave of that frequency is maximum. The amplitude of the waves emitted from the signal generator is varied or modulated due to the deviation in the frequency of the periodic force of the signal generator with the natural frequency of the acoustic surface. It is evident from Fig. 7 that AM is not possible when elytra are mutilated in steps. The reason is, the natural frequency of the elytron increases due to the reduction in its dimensions and may perhaps not fall in the frequency band of the signal generator. This confirms the assumption that AM of the signal is due to resonance phenomenon. The modulating frequency corresponds to the frequency of the elytral closing movement which is approximately 30 to 35 Hz. Further, it can also be noticed that the carrier frequency (frqeuency of signal generator) is not a single frequency but it is a band of frequencies in the audio range. Whereas the modulating frequency does not seem to give any acoustic impression.

Quality of sound: The quality of sound depends upon the number of overtones and their amplitudes present in the sound produced. It is well established in the present investigation that the elytron is vibrating with the forced oscillations of the signal generator (scraper-file system) and hence the overtones (10.5 and 16 KHz) present in the signal is due to the elytral vibrations alone. Fig. 10, the sonagram of the sound produced by *G. bimaculatus*, presents two overtones and a fundamental frequency which is pronounced.

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THE EXCRETION OF FREE AMINO ACIDS BY THE LARVA OF THE MOTH, *SPODOPTERA MAURITIA* BOISDUVAL

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Estimation on the content of free amino acids in the larval excreta of *Spodoptera mauritia* showed that they represent a minor constituent of the nitrogenous excretory waste. There was a tremendous increasa in the total amount of free amino acids in the excreta on anlysing the samples collected within a period of 24 h. It was concluded that the interval overlapped in the collection and processing of the excreta is critical in the estimation of free amino acids. The source of free amino acids in the excreta was suggested to be the products of digestion passively eliminated either by the excretory system or are eliminated as unabsorbad digestive waste. The true excretory nature of free amino acids in insects was questioned and the irrationality behind the concept of free amino acid excretion was discussed.

(Key words: spodoptera mauritia, free amino acids, excretion)

INTRODUCTION

The excretion of free amino acids in insects has been studied by many investigators (BURSELL, 1967; COCHRAN, 1975). These studies revealed that many free amino acids are eliminated through the excreta regardless of their importance and participation in the metabolism and of their non-toxic nature. Accordingly three major lines of thought have evolved in the past : (1) they are excretory in nature and are actively eliminated like other nitrogeous waste; (2) they are products of digestion passively eliminated either by the excretory system or eliminated as unbsorbed digestive waste and (3) their excretion is the result of food injested in excess of dietary requirements. The major problem encountered in the evaluation of the existing data is that the possible chances of microbial action on the excreta after being eliminated from the animal was generally overlooked in the past—the longer the period taken to collect / process the excreta the more are the chances of microbial action. This is further complicated by the fact that the excreta of insects is a heterogenous mixture of unabsorbed food materials and the substances eliminated from the body metabolic pool mainly by the combined action of malpighian tubules and rectum and is eliminated through a common opening of the alimentary canal, the anus. Therefore, it is difficult to distinguish between the true metabolic waste (endogenous) and the digestive waste (exogenous). Further, the materials in question are the direct product of the digestion of proteins or peptides or are abundant in the food materials and their chances of elimination through the unassimilated food materials as an unavoidable waste is quite obvious. The contribution

of microbial flora to the production of these materials inside the gut must also be envisaged. Therefore, a comparison between the composition of food materials and excreta are not entirely dependable data in determining their true excretory nature. In the present study attempts have been made to evaluate the excretion of free amino acids in the larva of *Spodoptera mauritia* during its development. Attempts have also been made to resolve the discrepancies in the available data on free amino acid excretion in insects and to evaluate the status (and / or importance) and the validity of the concept of the excretion of these nitrogenous compounds.

MATERIALS AND METHODS

The excreta was collected from chronologically comparable final instar larvae of *S. mauritia* at 24 h intervals from the time it started excreting to the time it stopped voiding faecal pellets. The fresh excreta collected within a period of 2 to 3 min. was immediately dried in an oven at 100°C for 1 h and then at 60°C to a constant weight. Excreta samples collected within a period of 24 h at room temperature and fresh samples of feed material, grass, were also processed in the same way.

The faecal pellets/grass were powdered and extracted repeatedly with 80% ethanol by reflexing at 60°C, cleared by centrifuging, supernatant concentreated at 60°C and used for analysis. Free amino acids in the samples were separated according to HIRS (1956) using two-dimensional thin-layer chromatography. After development, the plates were dried at room temperature, sprayed with nihydrin–cadmium acetate solution — 1% ninhydrin in acetone (100 vol) and a solution of 1% cadmium acetate in acetic acid +50ml water (15 Vol)—and again dried at room temperature. Then the plates were heated at 100°C for 5 min. The individual spots were identified and then gel eluted with 80% ethanol, cleared by centrifuging and the colour read. The colour intensities of the standard amino acids, co-chromatographed and processed as above, were measured separately for each amino acid and used for calibration of the respective amino acid in the sample. The total proteins

in the feed material was estimated on the basis of its total nitrogen content according to MUNRO & FLECK (1969). The total nitrogen was estimated according to MANN (1963).

RESULTS AND DISCUSSION

The amount of individual and total free amino acids in the larval excreta during its developmental stages are presented in Table.

Among the free amino acids found in the excreta alanine, aspartic acid, glycine, histidine, proline, threonine and tryptophan were predominant in the excreta. The levels of arginine, citrulline, glutamic acid, lysine, ornithine, phenylalanine and tryptophan were low in the excreta during all development stages. There was no characteristic pattern in the variation of individual amino acids at different stages, but, in general, their concentration increased with the development of the larva.

The estimation of total free amino acids in the excreta samples collected within a period of 24 h at room temperature showed spurious values (5000 to 8000 μg/g) and, therefore, the individual amino acids of the samples were not estimated. The total free amino acids in the feed material was found to be 2064.23 ± 428.00 μg/g (mean ± S D)

The results of the present study revealed that the free amino acid nitrogen represented only a minor fraction of total nitrogen of the larval excreta, when the microbial contamination of the material was checked before analysis. However there is the obvious possibility of their action inside the gut. On account of the continuous feeding and excretory nature of the larva it was assumed that the retention of food materials for a long period in the gut will be at a minimum (LAZAR, 1983). Therefore the chances of microbial production of amino acids in the gut of

Concentration of free amino acids in excreta.

Amino acids	μg/g, mean $\pm$ S D			
	0 h	24 h	48 h	72 h
Alanine	59.72 ± 11.18	54.06 ± 9.34	56.49 ± 8.76	67.48 ± 9.83
Arginine	55.57 ± 10.77	35.87 ± 6.21	25.39 ± 4.05	94.29 ± 15.94
Aspartic acid	151.18 ± 28.42	100.00 ± 19.83	112.33 ± 19.46	162.67 ± 22.07
Citrulline	35.56 ± 5.48	42.67 ± 6.44	45.69 ± 5.46	56.00 ± 9.66
Glutamic acid	40.20 ± 6.20	16.92 ± 3.37	45.37 ± 5.01	28.66 ± 3.88
Glycine	62.05 ± 9.20	69.74 ± 9.87	57.13 ± 9.94	136.51 ± 21.56
Histidine	108.13 ± 18.67	159.51 ± 27.54	190.12 ± 26.25	219.26 ± 23.97
Hydroxyproline	37.33 ± 5.96	54.67 ± 11.93	38.67 ± 5.58	260.00 ± 44.22
Leucine (and / or isoleucine)	67.10 ± 10.50	50.37 ± 7.55	59.85 ± 9.69	42.37 ± 8.24
Lysine	9.14 ± 1.73	9.52 ± 1.91	9.52 ± 1.51	9.14 ± 1.44
Methionine	61.50 ± 9.83	66.83 ± 11.00	37.67 ± 3.46	123.83 ± 16.93
Ornithine	6.94 ± 1.95	13.61 ± 2.72	7.08 ± 1.14	9.25 ± 1.41
Phenylalanine	41.46 ± 5.65	46.03 ± 8.03	54.25 ± 11.12	62.10 ± 9.31
Proline	95.56 ± 13.96	120.74 ± 18.44	180.00 ± 28.40	72.59 ± 13.25
Threonine	88.53 ± 14.62	72.80 ± 15.28	105.20 ± 14.79	67.47 ± 10.61
Tryptophan	35.27 ± 7.07	34.84 ± 7.85	43.87 ± 7.94	132.90 ± 27.09
Tyrosine	124.44 ± 20.79	80.49 ± 13.45	65.93 ± 10.82	191.11 ± 24.67
Total	1079.68	1028.67	1134.56	1735.63

Five samples each were used in the measurements.

the larva will also be at a minimum level. Interestingly, a tremendous increase in the total content of free amino acids in the excreta was found on analysing the samples collected within a period of 24 h. This observation clearly points to the magnitude of the possible error in the analytical results of the samples collected at long intervals in the past.

The passive elimination of amino-acid through the gut has been advocated by MADDRELL (1971, 1981). The results of the present study are in conformity with the above view. On account of the high protein diet (a gross evaluation of the protein content of the feed material showed that it is very rich in proten-about 72% of the dry weight) and the short intervals that the larva retains the food in the alimentary canal, there is every possibility of the passive elimination of some of the products of the digestion of proteins through unassimilated food by the larva of *S. maurita*.

The excretion of small to moderate amounts of the amino acids as a resul

of their ingestion through food in excess of dietary requirement has been demonstrated in insects (AUCLAIR, 1963; COCHRAN, 1975). But a close observation on the methodology adopted in these investigations revealed that many have taken neither sufficient measures against microbial contamination before analysing the material nor have given due consideration to their origin as a digestive waste before arriving at the conclusions It may be noted that the conclusions on the true excretory nature of free amino acids in honey dew were mainly based on the comparison of the composition of the plant sap to that of the excreta. Barring all such possibilities, it can be seen that in most of the cases, amino acid fraction of the total nitrogen of the excreta is very small.

However, special attention has to be given to the reports on the high level of certain amino acids in the excreta The preponderance of sulphur containing amino acids in the excreta of the wool eating insect, *Tineola bisselliella* (POWNING, 1953) can be evaluated in the context of their high sulphur containing diet. The excretion of large amounts of histidine and arginine in the excreta of the tsetse fly, *Glossina morsitans* (BURSEL, 1965) and of the mosquito, *Aedes aegypti* (FRANCE & JUDSON, 1975) are difficult to evaluate on account of the time taken (24 h and 72 h respectively) in the collection and processing of the excreta. The high content of histidine observed in the pupal meconium of the tobacco hornworm, *Manduca sexta* (LEVENBOOK *et al.*, 1971) can be evaluated in the context of the relative predominance of amino acids in the haemolymph of holometabolous insects (LAZAR, 1983). As the larval haemolymph contains a very high content of histidine its passive elimination through the excretory system is quite obvious. Thus, on the whole, the selective elimination of amino acids can be explained as a reflection of their dietary nature, haemolymph composition and physiological state. In all the above instances this can be correlated to its passive elimination as suggested by MADDRELL (1971, 1981). On the other hand, if the selective elimination of the nutritionally essential amino acids like arginine, histidine or lysine or the active elimination of other protein amino acids are to be taken for granted as a means to eliminate the excess nitrogen, the serious consequences arising out of it have to be explained. Further it contradicts well the concept of nutritional essentiality in insects (DADD, 1973) and the very concept of excretion. (MADDRELL, 1971).

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DESCRIPTION OF A NEW SPECIES OF *CENTRODORA* FOERSTER AND NOTES ON THE TYPES OF *ERETMOCERUS DELHIENSIS* MANI (HYMENOPTERA : CHALCIDOIDEA : APHELINIDAE)

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A new species of the genus *Centrodora* Foerster *(C. bifasciata* sp. nov.) is described based on two specimens collected in the Indian State of Assam. Notes are provided on the types of *Eretmocerus delhiensis* Mani and *E. mashhoodi* Hayat is placed in synonymy with that species.

(Key words· Aphelinidae, new *Centrodora* species, identity of *Eretmocerus delhiensis)*

Eretmocerns delhiensis Mani (Figs 1–3)

Eretmocerus delhiensis Mani, 1941 : 35. ♂ = ♀. India, New Delhi (Indian Agric. Res. Inst. New Delhi), examined. Lectotype designated.

Eretmocerus mashhoodi Hayat, 1972 : 102. ♀ ♂. India, Aligarh (Zoological Survey of India, Calcutta. Paratypes in Hayat coll.) syn. nov.

E. delhiensis: The types consist of two specimens mounted on a slide under a single coverslip. These are females, not males as mentioned by Mani (1941), (but see his Fig. 4 d). The slide bears three labels : 'Eretmocerus delhiensis Mani', 'TYPE Series 2 ♂♂', and 'PCS 192. From nymphs of a new Aleyrodis IARI New Delhi MS Anwar coll. 7-XII. 33'. The IARI registration number (278/39) is written on the third label.

There is some discrepancy between the published data and that given on the slide. The year of collection and the host as given in the original description

are 1938 and *Neomaskellia bergii.* But these are the only specimens extant in the IARI under the name *Eretmocerus delhiensis* and I regard these as syntypes. Since Mani did not designate a holotype, I have selected and designated the larger specimen (length, ca 0.55 mm) as the Lectotype. The second specimen is smaller (ca 0 45 mm) in size.

The species has remained unrecognized so far because of the poor and inadequate original description. The two specimens are skrunken and partly distorted and, therefore, their actual lengths should be greater than those given above. The antennae are partly shrunken, or otherwise distorted so that Figs 1 and 2 do not show the relative dimensions of the segments accurately. In spite of the condition of the types, *delhiensis* can be recognized by the following combination of characters: Antennal radicle longer than half the length of scape and shorter than the dorsal length of pedicel; pedicel (ventral length) about 2.5 × as long as
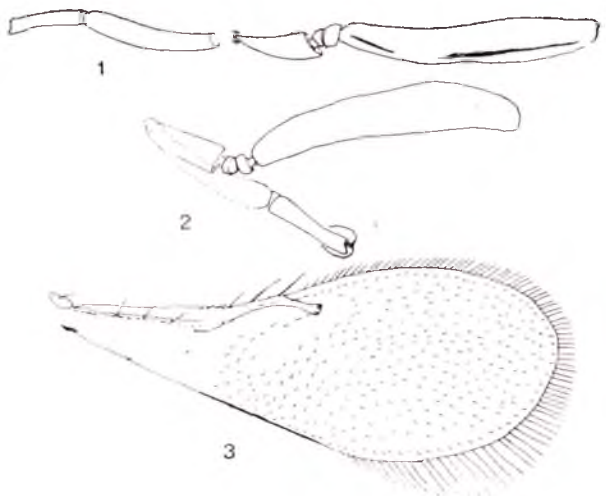
Figs 1-3 *Eretmocerus delhiensis* Mani : 1. Antenna, paralectotype; 2. Antenna, lectotype; 3. Fore wing, lectotype.

wide, but dorsal length slightly more than 3 × as long as wide; mid lobe of meso-scutum with 6 setae and scutellum with the usual number (4) of setae; forewing in lectotype as in Fig. 3, in the parale-ctotype the longest marginal fringe nearly one-third the width of wing; mid tibial spur nearly half as long as the correspond-ing basitarsus. Other details are impossible to see in the types.

Comments: Among the Indian species of the genus *Eretmocerus* I consider *E. mashhoodi* Hayat (1972) a junior synonym of *delhiensis*. Except for the relatively larger size (0.75—0.87 mm, not 0.91 mm as given in the original description) and the differences associated with size (for instance, the longest marginal fringe of forewing in *mashhoodi* is about one-fourth of width of wing), I find no appreciable character to separate these two species. Another possible synonym would be *E. hydrabadensis* Husain and Agarwal (1982), but the original description of that species

appears totally incorrect (scutellum with 6 setae, linea calva proximally bordered by about 20 setae, gaster dark brown, etc.). The types of this species are not available and, therefore, I hesitate ot give a definite opinion.

Distribution: India: New Delhi (Mani, 1941) Uttar Pradesh (Hayat, 1972; Khan and Shafee, 1980), Bihar (Prasad, 1954). Pakistan: Peshawar (Viggiani, 1985).

Hosts: Neomaskellia bergii (Signoret) (Khan and Shafee, 1980; Prasad, 1954; Mani, 1941, but see comments above); indet aleyrodids (Hayat, 1972); *Neomaskel-lia* sp. (Viggiani, 1985).

Centrodora bifasciata sp. nov. (Fign. 4-9)

Female: Length approximately 1.3mm.

Head with frontovertex orange yellow, ocellar triangle brown, around and bet-ween antennal toruli pale yellow, cheeks pallid with brown suffusions; occiput brown; tips of mandibles dark brown; palps pallid. Antennal scape yellow,

pedicel brown, flagellum drak brown. Exposed part of pronotum and axillae pallid; mid lobe orange anteriorly to yellow brown posteriorly; scutellum yellow brown a pale mid–longitudinal line from apex of mid lobe to apex of propodeum; metanotum on sides and propodeum mesad of spiracles (except the pale line in middle) dusky brown; propodeum whitish on sides; mesopleura dusky or pale brown above; petiole pale brown. Gaster with basal three–fourths of tergum I and terga V and VI dark brown, shiny; distal quarter of tergum I, terga II–IV yellow, tergum VII pallid; ovipositor sheaths (= third valvulae) pallid. Fore wing (Fig. 8) hyaline below submarginal vein, yellow otherwise with two infuscated bands, one below proximal two–fifths of marginal vein and the other distad of venation, the latter gradually becoming yellowish brown towards apex of wing; hind wings hyaline. Fore and mid legs including coxae yellow; hind coxae except narrowly at base, dark brown; hind femora brown, tibiae darker yellow; all tarsi white or pale yellow. (The description of colour
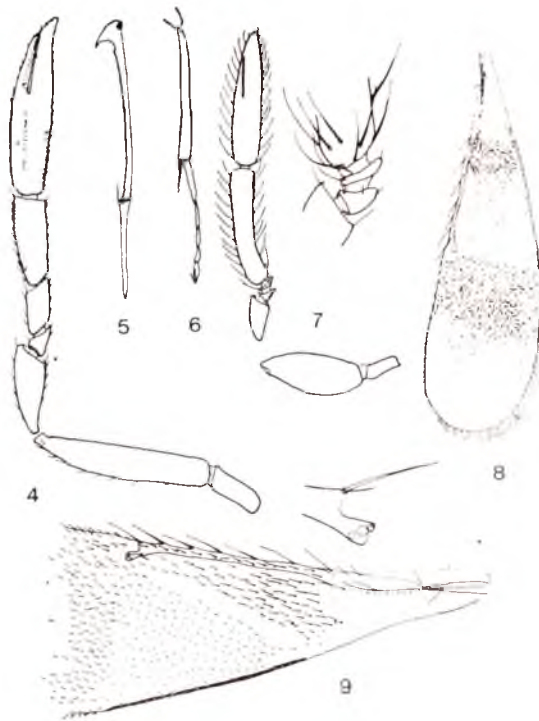
Figs 4–9 *Centrodora bifasciata* sp. nov.: 4. Antenna, female; 5. Second valvifer and third valvula; 6. Mid tibia and tarsus, female; 7. Scape from left antenna, pedicel and flagellum from right antenna with funicle enlarged and shown separately, male; 8. Fore wing showing infuscation, female; 9. Basal half of fore wing showing setation, with stigmal vein enlarged and shown separately from right wing, female. Fig. 7 from paratype, rest of the figures from holotype. Figs. 5, 6 and 8 drawn on same scale.

was noted before clearing and mounting the specimen on a slide.)

Frontovertex two-fifths of head width with dark prominent setae, those behind lateral ocelli longer, ocellar triangle with apical angle obtuse, lateral ocelli separated from eye margins by slightly less than the diameter of an ocellus; antennal toruli with their upper margins slightly above a line drawn across lower eye margins; mandibles tridentate, the upper tooth shorter, and with a small receded truncation. Antennae as in Fig. 4.

Thorax characteristic for the genus; pronotal collar with two longer and 1-2 shorter setae on each side; mid lobe of mesoscutum, each side lobe, each axilla and scutellum with 10 (2 + 4 + 2 + 2), 1 and 4 setae; mid lobe about one and one third times as long as scutellum; scutellum nearly $1.5 \times$ as wide as long median length of metanotum about one-fourth that of scutellum; propodeum long, its median length about twice that of metanotum; propodeum with a fine carina on each side mesad of spiracles and with a pair of minute setae adjacent to the outer side of each spiracle. Fore wing dimensions and details of setation as in Figs. 8 and 9. Legs normal for the genus; first and second segments of fore tarsi subequal in length, those of mid (Fig. 6) and hind legs with first segment longer than second segment.

Gaster as long as head plus thorax, tergum VII elongate; ovipositor shortly exserted, the exserted part about one-fifth the length of gaster (After clearing and mounting on a slide, the gaster appears distinctly longer than head plus thorax and ovipositor only very shortly exserted.). Second valvifer and third valvula combined slightly more than twice as long as mid tibia (Figs. 5, 6), third valvulae more than half the length of second valvifer.

Male: Length approximately 1.1mm.

Body dark brown, shiny; frontovertex and occiput above foramen yellow with some orangetinge; face yellow; pronotum brown, collar pale brown; anterior margin of mid lobe, side lobes, and a mid-longitudinal line running from mid lobe to apex of propodeum, orange; otherwise thoracic dorsum brownish, a little shiny; petiole pale yellow brown; gaster dark brown, shiny with only apical half of tergum VII pallid. Antennal radicle, scape and pedicel brown, flagellum yellow to pale yellow brown. Wings about as in female; the distal infuscated band of fore wing rather faint. Legs brownish including fore and mid coxae; hind coxae dark brown; fore and mid tibiae relatively less darker than hind tibiae; mid and hind tarsi brownish.

Structurally similar to female except for the following characters: Frontovertex about a half as wide as head width; antennae as in Fig. 7; mid lobe of mesoscutum with 12 (2 + 2 + 4 + 2 + 2) setae; forewing with 2 setae below parastigma in the basal cell; gaster more or less parallel-sided up to tergum V, then gradually narrowed to apex; tergum VII conical, about $1.5 \times$ as wide as its median length, and relatively less elongate than in female.

Holotype: ♀ (on a slide, with wings and left antenna detached and mounted on the same slide) : INDIA: Assam, Guwahati, Baraduai, 17. v. 1986 (Coll. Sudhir). Paratype: 1 ♂, same data as holotype (partly dissected and mounted on a slide).

The type material is retained in the author's collection pending deposition in a museum.

Comments: *Centrodora bifasciata* sp. nov. belongs to *C. amoena*-group *(oophaga, locustarum, dorsati, hexatricha, speciossima, xiphidii)* characterized by having the antennal clava in female with more or pointed and ventrally curved apex, presence of a linea calva in the fore wings, and in the male the antennae with the basal two funicle segments anelliform, third segment elongate, at most slightly shorter than clava, and both provided with long setae. The new species differs from all these species by the specific type of fore wing infuscation. In none of these species the fore wings are bifasciate. (Ferriere, 1965; Hayat, 1981; and Waterston, 1917 should be consulted for details on these species.)

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ON A NEW SPECIES OF GENUS *PARISOMIAS* FAUST (COLEOPTERA, CURCULIONIDAE, BRACHYDERINAE)

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A new species of genus *Parisomias* Faust, *P. minutisquomosus* sp. nov. has been described.

(Key words: new species, *Parisomias)*

INTRODUCTION

The authors have made extensive studies on the Brachyderinae of India during a 5 year P. L. 480 project. Ninety nine species including 28 new species of this subfamily were procured and described. Some of the new species have already been seported (Gandhi and Pajni, 1984a, b, c; Pajni and Gandhi 1984a, b). One of the new species falls under genus *Parisomias* Fst. which is being reported in this communication

The genus *Parisomias* Fst. was for a long time considered as a synonym of *Leptomias* Fst. (Marshall, 1916; Gunther and Zumt, 1933; Emden, 1944). Aslam (1961), however, revalidated this genus and later on gave a key to the then known 32 species from Indo-Pakistan area including 23 new species (Aslam, 1969). The present species is different from the described species. Its relationship with the allied species has been discussed.

The genus *Parisomias* Fst. is characterized by the open corbels and long metasternum equal to or longer than mesocoxae (Aslam, 1961). It can be separated from *Leptomias* Fst. which has enclosed corbels and short metasternum not longer than the diameter of mesocoxae. Both the genera belong to the Tribe Tanymecini which is characterized by the presence of vibrissae on anterolateral margins of prothorax (Marshall, 1916).

Parisomias minutisquomosus sp. nov. (Figs. 1 and 2)

Head with frons shallowly punctate, with a deep and narrow median furrow ascending vertex. Eyes circular, convex and prominent. Rostrum as long as broad, broadest at apex; upper surface shallowly punctate, with a deep and narrow median furrow; mandible scar conspicuous; mentum with two setae. Antennae with scape gradually clavate, reaching front margin of eye; funicle with two basal joints almost of equal length.

Prothorax a little broader than long, broadest before middle, truncate at base and apex, apex scarcely narrower than base; upper surface finely granulate; pattern formed by brown scales mingled with short and subdepressed setae. Thoracic sterna covered with brown scales and suberect setae; forecoxae contiguous, near
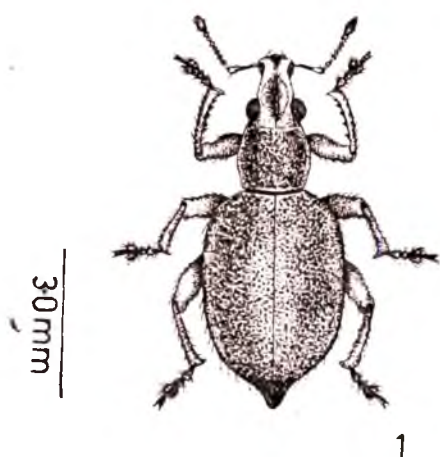
Fig. 1. Adult of *Parisomias minutisquomosus* sp, nov.

ADA, Aedeagal apodemes; AED, Aedeagus; PHB, Phallobase; PHBA, Phallobasic apodeme; PMR, Parameres.

to anterior margin of prosternum; metasternum almost as long as midcoxae.

Elytra broadly oval, without distinct shoulders, base shallowly sinuate margins narrowly elevated, apices narrowly rounded; surface shallowly punctato–striate, striae diminishing towards apex, intervals smooth, broader than striae; pattern formed by dark green and black scales, short and subdepressed setae. Legs with front tibiae dentate internally, mid and hind tibiae finely serrate, corbels open; claws connate.

Abdomen with visible sternite 2, a little shorter than 3 and 4 together, separated from 1 by a deep angulated furrow; apical sternite compressed in middle and narrowly pointed.

Male genitalia with aedeagus sclerotized, apex narrowly pointed; aedeagal apodemes shorter than aedeagus; phallotreme subapical; phallobasic apodeme
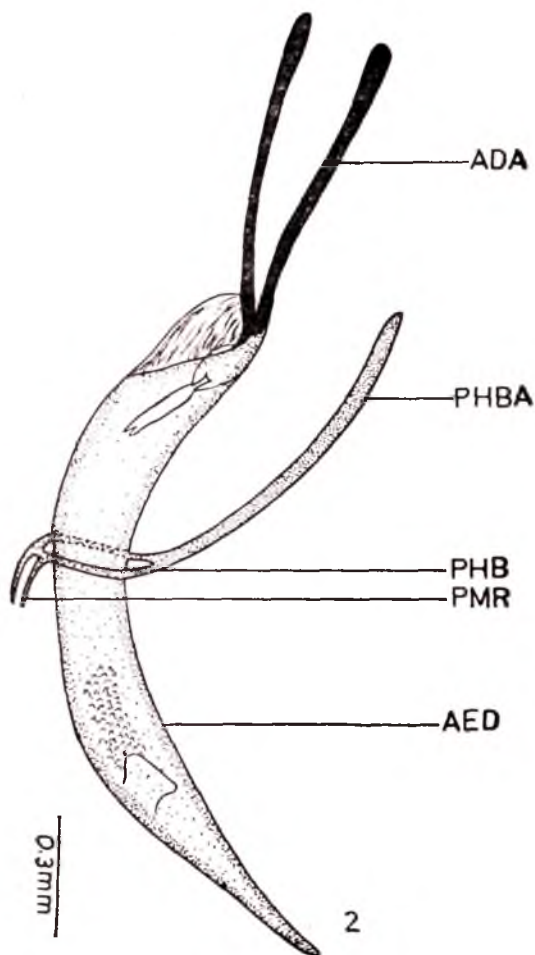
Fig. 2. Male genitalia of *P. minutisquomosus* sp. nov.

(for abbreviations, see Fig. 1.)

thicker, almost as long as aedeagal apodemes; parameres short; endophallus with well developed sclerotized structure near base.

Measurements: ♂: Length of rostrum. 0.9 mm. Width of rostrum, 0.9 mm. Length of body, 7.5 mm. Width of body, 3.0 mm.

Holotype: Male: Kashmir, Liddermat and half way to Kolahoi Glacier (from under stones), 6–7.v.1967, Dr. G. Topal

(Holotype deposited in Entomology Section, Deptt. of Zoology, Panjab University, Chandigarh).

Remarks: This species, when followed through the key of Aslam (1969), reaches *dalhausiensis* Aslam. However, there are marked differences in the antennae and elytra of the two species. First two joints of the funicle in *P. minutisquomosus* sp. nov. are equal but joint I is a little longer than 2 in the funicle of *P. dalhausiensis* Aslam. Moreover, the odd intervals in the elytra of *P. dalhausiensis* Aslam are distinct and all intervals are narrower than striae. In *P. minutisquomosus* sp. nov., on the other hand, all the intervals are distinct and broader than striae.

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PREDATORS AND PARASITES OF APHIDS FROM NORTH WEST AND WESTERN HIMALAYA. II. RECORDS OF EIGHT APHIDOPHAGOUS NEUROPTERANS (INSECTA) FROM INDIA

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Eight species of chrysopid neuropteran as predators of 13 species of aphids on 11 different host plants from Garhwal and Kumaon ranges of Western Himalaya, India are newly reported in aphid association from India

(Key words: aphidophagous neuropterans, Garhwal and Kumaon Himalaya, aphid prey range, season)

Aphidophagous neuropterans are very poorly represented from India through the scratchy works of Rahman (1940), Rahman and Khan (1941), Behura (1963, 1965), Rao (1969), Ghosh *et al.* (1981) and Das and Raychaudhri (1983). From the above accounts, so far, only 8 species of chrysopids, coniopterygids, and hemerobiids are known to predate on 13 species of aphids in India. Another 8 aphidophagous neuropteran species collected from Garhwal and Kumaon ranges of Western Himalaya, India are newly recorded in aphid association from India. Besides these new records, *Chrysoperla carnea* (Stephens) predating upon 9 aphid species, and 3 samples identified upto generic level viz. *Anisochrysa* sp. on 4 aphid species, *Hemerobius* sp. on 1 aphid species and *Micromus* sp. on 3 aphid species are also known from the area. Now with this account, the number of aphidophagous neuropteran fauna of India stands at 16.

During the years 1982–1985 neuropteran larvae feeding on aphids were collected from the field of Garhwal and Kumaon ranges of western Himalaya. These were reared out with appropriate aphid hosts. Some pupae were also obtained from the aphid colony. The adults thus emerged out of these larvae and pupae were later identified. The neuropteran material and also aphid samples are presently deposited in the collection of Biosystematics Research Unit, Department of Zoology, University of Kalyani.

The names of the newly recorded aphidophagous neuropterans are listed below. The name of the host plants of aphids are given in parenthesis.

1. Anisochrysa boninensis (Okamoto)

Prey aphid: *Greenidea (Trichosiphum) formosana heerii (Psidium guajava).*

Season : August. Locality : Kapkot (Kumaon)

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2. Anisochrysa obvia Holzel

Prey aphid : *Rhopalosiphum* sp. (unidentified grass).

Season : April : Locality : Joshimath (Garhwal).

3. Chrysopa dasyphlebia (Mclachlan)

Prey aphids : *Betacallis sikkimensis (Betula alnoides; Eumyzus pruni (Prunus cornuta)*.

Season : June. Locality : Badrinath (Garhwal), Khati (Kumaon).

4. Chrysopa himalayana Ghosh

Prey aphid : *Chromaphis hirsutustibis (Juglans regia)*.

Season : September. Locality : Govindghat (Garhwal).

5. Chrysopa murreensis Tjeder

Prey aphid : *Lachnus* sp. *(Cedrus deodara)*.

Season : October. Locality : Gongotri Garhwal).

6. Chrysopidia garhwalensis Ghosh

Prey aphid : *Lachnus* sp. *(Cedrus deodara)*.

Season : October. Locality : Gongtri Garhwl).

7. Cunctochrysa jubingensis Holzel

Prey aphids : *Aphis kurosawai (Artemisia vulgaris; Brevicoryne brassicae (Brassica campestris); Chaitophorus kapuri (Populus ciliata); Greenidea (Trichosiphum formosana heerii (Psidium guajava); Pemphigus mordvilkoi (Populus ciliata); Mollitrichosiphum* sp. *(Alnus nepalensis)*.

Season : June—September. Locality : Joshimath, Lambagar (Garhwal); Chaubatia, Loharkhet, Kopkot (Kumaon).

8. Italochrysa aegualis (Walker)

Prey aphid : *Greenidea (Paragreenidea) parthenocissi (Parthenosisus semicordata)*.

Season:June, Locality:Osla (Garhwal).

The role of chrysopids in controlling several aphid pests is well known (Beglyarov and Uschkov, 1974. Obviously, we felt the need of proper exploration of aphidophagous neuropteran fauna during a survey of aphid and their natural enemies in Western Himalaya, India. Till now, most of the works done are on the predatory efficiency and field utilization of a cosmopolitan species, *Crysopella carnea* (Afzal and Khan, 1978; Baumgaertner *et al.*, 1981; Rautapaa, 1977; Ridgway and Jones, 1968; Scopes, 1969; Tulisalo and Tuovinen, 1975; Tulisalo *et al.*, 1977). In the present area of study. *C. carnea* also feeds on a maximum (9) number of aphid species. The 8 species recorded here feed on 13 different aphid host infesting 11 host plants.

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LIFE-TABLE AND INTRINSIC RATE OF INCREASE OF *SPODOPTERA LITURA* FABRICIUS ON CASTOR AND COTTON

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The rate of multiplication of tobacco cutworm, *Spodoptera litura* Fabricius was studied on upland cotton, *Gossypium hirsutum* Linnaeus and castor, *Ricinus communis* Linnaeus at 26° ± 2°C. The net reproductive rate (R_0) of *S. litura* was 547.18 on castor and 358.76 on cotton. The intrinsic rate of natural increase (rm) was 0.1935 on castor and 0.1465 on cotton while the finite rate of increase (γ) was 1.213 females per day on castor and 1.158 on cotton. The doubling time (DT) of the population was 3.590 days on castor and 4.725 days on cotton and it was able to multiply 3.864 times on castor and 2.725 times on cotton per week. When *S. litura* reached stable age distribution, its eggs, larvae, puape and adults contributed to 54.817, 43.286, 1.639 and 0.258 per cent on castor and 53.235, 45.229, 1.324 and 0.212 per cent on cotton respectively.

(Key words: life-table, intrinsic rate of increase, stable age distribution, *Spodoptera litura*, castor, cotton)

INTRODUCTION

Life-table is a concise summary of certain vital statistics of insect population, a useful technique in the study of population dynamics which provides a format for recording and accounting of all population changes in the life-cycle of a species in its natural environment (Bilapate & Pawar 1978). Deevey (1947) and Morris & Muller (1954) conducted life-table studies to determine the distribution of insects and causes of mortality during different developmental stages. Attempts have been made earlier to study the net reproductive rate (R_0) of *Heliothis armigera* Hubner on 12 hosts (Pretorius, 1976), the innate capacity of increase (rm) and finite rate of increase (λ) of *H. armigera* on lucerne, *Medicago sativa* L. (Bilapate *et al.*, 1977); the life-table of *H. armigera* on pea, *Pisum sativum* L. (Bilapate & Pawar, 1978); on limabean, *Phaseolus lunatus* L. (Bilapate *et al.*, 1978); on cotton *G. hirsutum*; sorghum, *Sorghum bicolor* (L.) Moench; tomato *Lycopersicon lycopersicum* (Lin.) Karst and redgram, *Cajanus cajan* L. (Dhandapani, 1979). An attempt was made to study the life-table and intrinsic rate of increase of *S. litura* on *R. communis* and *G. hirsutum*.

MATERIALS AND METHODS

Life-table studies on *S. litura* were made using castor and cotton as host plants under laboratory condition. Known number of adult pairs was released for egg laying in cages. Eggs laid on white muslin cloth were collected using wet camel hair brush and 100 eggs were kept for hatching. Immediately on hatching,

the larvae were transferred to respective feeding material kept in plastic containers (5 × 5 cm). The food was renewed daily in the morning till all the larvae pupated. The adults that emerged on a particular day were paired and released in separate cages for egg laying. The fecundity of the females on subsequent days was noted daily till all of them died.

To determine the number of females borne (m×) out of the eggs laid per female, the sex ratio of 1 : 1.29 for castor and 1 : 1.33 for cotton was utilised. Observations on hatching of eggs till the emergence of adults were recorded daily which provided the values for the life-table (lx).

The life-table was prepared according to the method of BIRCH (1948) elaborated by HOWE (1953) and ATWAL & BAINS (1974). The innate capacity for increase (rm), net reproductive rate (R_o) and mean generation time (T) were the basic population parameters used to assess the population growth in the laboratory at $26 \pm 2°C$. The value of rm was calculated by using the formula $\sum e^{7-rmx}$ lxmx = 1096.6. Stable age distribution (percentage of various age groups) was worked out by calculating the population. schedule of birth rate and death rate lx and mx when grown in a limited space.

RESULTS AND DISCUSSION

The pre–oviposition period ranged from 30 to 32 days on castor and from 37 to 39 days on cotton. The survival of immature stages (l x) from egg to adult emergence was 0.71 on castor and 0.63 on cotton. The oviposition started on 33rd day on castor and 40th day on cotton. Mortality in the larval stage was encountered due to viral infection. The first female mortality was observed on 8th day on castor (l x = 0.58) and on 7th day on cotton (l x = 0.53) after emergence of the adults and increased thereafter. The adults attained greatest mean progeny production per day (m×) of 241.5 on 35th day on castor and 163.88 on 40th day of pivotal age on cotton. Five days after oviposition, the reproduction ceased. The net reproductive rate (R_o) representing the total female births was 547.18 on castor and 358.76 on cotton (Tables 1 and 2).

The mean genaration time (TC) was 34.57 days on castor and 41.40 days on cotton. The innate capacity for increase (rm) was 0.1935 on castor (Fig. 1) and 0.1465 on cotton (Fig. 2) while the finite rate of increase (λ) was 1.200 and 1.153 / female / day on these hosts, respectively. The doubling time (DT) of the
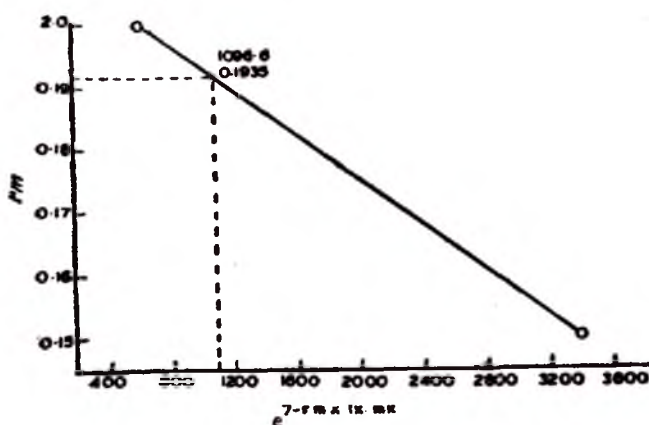
Fig 1 Determination of the intrinsic rate of increase (rm) on castor.

TABLE 1. Age specific fecundity life-table (for females) for *S. litura* on castor.

Pivotal age (days) X	survival of females at age X 1×	age schedule for female births at age X m×	1×m×	X 1×m×
0—29	0.71	immature stages		—
30	0.71	×	0.71	21.30
31	0.71	×	0.71	22.01
32	0.71	×	0.71	22.72
33	0.71	170.52	121.07	3995.28
34	0.71	190.82	135.48	4606.39
35	0.71	241.50	171.47	6001.28
36	0.58	148.68	86.23	3104.44
37	0.55	56.00	30.80	1139.60
38	0.47	0.00	0.00	0.00
		Σ lxmx (R$_o$) =	547.18	Σx = lxmx 18913.02

TABLE 2. Age-specific fecundity life-table (for females) for *S. litura* on cotton.

Pivotal age (days) X	survivol of females at age X 1×	age schedule for female births at age X m×	1×m×	X 1×m×
0—36	0.63	immature stages		—
37	0.63	×	0.63	23.31
38	0.63	×	0.63	23.94
39	0.63	×	0.63	24.57
40	0.63	163.88	103.24	4129.78
41	0.63	133.24	83.94	3441.59
42	0.63	157.46	99.20	4166.39
43	0.53	107.59	57.02	2451.98
44	0.45	29.93	13.47	592.61
45	0 33	0.00	0.00	0.00
		Σ lxmx (R$_o$) =	358.76	Σ x lxmx = 14854.17

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TABLE 3. Generation time, innate capacity for increase and finite rate of increase in number of *S. litura* on castor and cotton.

Parameter	value on	
	castor	cotton
Mean length of generation TC (days) $= \dfrac{\Sigma \, x \, l \, x \, m \, x}{R_o}$	34.57	41.40
Innate capacity for increase in numbers (calculated) $r_c = \dfrac{Log_e \, R_o}{TC}$	0.1823	0.1420
Arbitrary rm (rc)	0.15 to 0.20	0.10 to 0.15
Corrected rm (graphically) $\Sigma \, e^{\,7-rmx} \; lxmx = 1096.6$ (females/day)	0.1935	0.1465
Corrected generation time (days) $T = \dfrac{log_e \cdot R_o}{rm}$	32.58	40.15
Finite rate of increase $\lambda =$ antilog e^{rm} / female / day	1.213	1.158
Weekly multiplication of the population $= (e^{rm})7$	3.864	2.792
Doubling time (DT) (days) $= \dfrac{log \, 2}{log \, \lambda}$	3.590	4.725
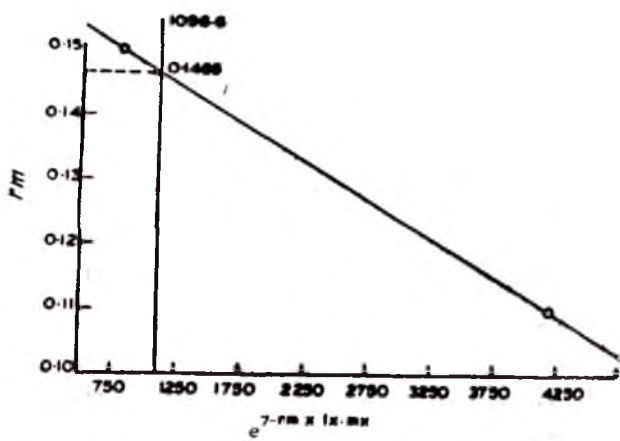
Fig. 2. Determination of the intrinsic rate of increase on cotton.

population was 3.800 days on castor and 4.878 days on cotton. The population could multiply 3.585 times on castor and 2.704 times on cotton per week (Table 3).

The contribution made by different developmental stages *viz.*, eggs, larvae. puape and adults of *S. litura* towards the stable age distribution was 54.187, 43.286, 1.639 and 0.258 per cent on castor and 53.235, 45.229, 1.324 and 0.212 per cent on cotton, respectively. Hence, it is understood that castor may serve as a better host compared to cotton to obtain higher fecundity of female in a short period.

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BIOLOGY OF REPRODUCTION OF *APANTELES TARAGAMAE* WILKINSON (HYM : BRACONIDAE) A LARVAL PARASITOID OF *OPISINA ARENOSELLA* WALKER, THE CATERPILLAR PEST OF COCONUT

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The female of *Apanteles taragamae* Wilkinson lays maximum number of eggs on the second day of its emergence. For oviposition, the parasitoid prefers the host larvae confined within their own galleries. The second instar is preferred best and the frass left by them acts as a strong attractant to the female parasitoid The whole act of one oviposition in *A. taragamae* is completed in 6.05 seconds.

The male: female ratio varied from 1:1 to 2:3, the females invariably showing a higher proportion in the population of the species. The shortest duration required by the parasitoid to complete the development from egg to adult has been found th be 15 days. This occurs in hot months, whereas in cold weather the parasitoid takes 24 days to complete the same

(*Key words :* *Apanteles taragamae, Opisina arenosella*, parasitoid, reproductive biology)

INTRODUCTION

Braconid parasitoids have been known to function as potential biocontrol agents against a number of harmful pests of agriculture and forest plants. Among the braconid parasitoids of *Opisina arenosella*, the caterpillar pest of coconut, *Apanteles taragamae* is one of the most important larval parasitoids attacking the early stages of the pest (Rao *et al.*, 1948; Nirula, 1956; Ghosh & Abdurahiman, 1985). Only very little work has been done on this parasitoid, probably due to the difficulty experienced to rear them under laboratory conditions (Nirula, 1956; Rao *et al.*, 1948; Mohamed *et al.*, 1982). Since more information on its reproductive biology is essential for the successful utilization of this parasitoid in biocontrol programmes, the present studies were undertaken.

MATERIALS AND METHODS

The following procedure has been followed in order to rear the parasitoid for biological studies,

The cocoon of *A. taragamae* collected from the field were employed to start the laboratory culture. The parasitoid thus emerged were fed on 50% honey solution. The mating behaviour was observed by placing newly emerged virgin females and males in specimen tubes of sizes 15 × 2 cm. The females were provided with suitable hosts to carry out observations on their oviposition. A Carl-Zeiss stereomicroscope was used for observing the behaviour. An average number of 50 observations were made in each case.

Twentyfive second instar host larvae *(O. arenosella)* along with their galleries on the coconut leaflets were cut into size of 0.5 × 3 cm, without disturbing the larvae present inside the gallery. These were introduced into the oviposition tubes of size 12 × 2 cm, each containing 10 mated females of the parasitoid,

Soon after oviposition the host larvae were transferred into fresh coconut leaf strips taken in glass tubes of size 15×2 cm. On every alternate day the leaf strips were removed and fresh strips were introduced until the final instar larva of the parasitoid emerged from the parasitised host larva. The pupae thus obtained were collected in separate tubes of size 10×2 cm. The adults emerged were provided with 50% honey as food. The process was repeated till sufficient number of the parasitoid was obtained.

The effect of the parasitoid number on the host was srudied by providing 50 host larvae to varying numbers of parasitoid females (1 to 10 numbers parasitoid females/50 host larvae) taken in tubes of 10×2 cm. After 24 hours, all the host larvae were removed and reared on fresh coconut leaf strips. The number of host larvae died and the percentage of mortality was calculated.

Various stages of development, viz., the egg, larva and pupa and their duration were observed by dissecting the parasitised host larvae at regular fixed intervals. The immature stages were determined by measuring the sizes of the mandibles, spiracles, head capsules etc. The morphological studies were made using Zeiss research microscope. All experiments and observations were conducted under laboratory conditions (temperature, $28 \pm 2°C$ and Relative Humidity, $57 \pm 5\%$).

OBSERVATIONS

1. Mating

The females were found to be receptive soon after emergence and in most cases mating occurred immediately after emergence. The wing turning, a typical component of the braconid mating behaviour, was found to occur in this case also. When the male comes close to the female (within a range of about 0.75 cm) it recognises the mate, and with a jump holds the female and mounts on it. The male usually makes a firm grip on the female. Soon after mounting, the male curves and extends his abdomen downwards and if the female remains motionless copulation takes place. The mating is accomplished in 35 to 50 seconds. The male can copulate with several females, whereas a female mates only once.

2. Oviposition

The female starts to oviposit 60 to 80 minutes after emergence. The parasitoid prefers to lay eggs in the early stage larva of O. arenosella. When it comes close to the host gallery, the female flies or walks towards it. On reaching the gallery, she walks about tapping the gallery with her antennae, occasionally inserting the ovipositor into it. Consequently the host larva becomes excited and moves out of the gallery. The parasitoid chases and catches the escaping host, curves the abdomen ventrally and quickly inserts its ovipositor into the body of the host larva. In some cases, the parasitoid oviposits while the host larva is still inside the gallery. During the process of oviposition the host larva exhibits contraction. The act of oviposition is completed in 6.05 ± 2 seconds.

When one egg is laid the parasitoid usually waits for some time before a second larva is parasitised. But in some cases, immediately after withdrawing the ovipositor from one host it chases another host and oviposits in it. When one gallery has been thoroughly searched, the female Apanteles flies or walks to a nearby gallery and repeats the same act. The parasitoid lays maximum number of eggs on the second day of its emergence. Usually a single egg is deposited in the haemocoel of the host, but occasionally 2–3 eggs are laid within a host.

Observations have indicated that the parasitoid very rarely oviposited for the second time in the same host larva. When the number of parasitoids per host (parasitoid–host ratio) is increased, a

higher larval mortality is noticed. All of the dead host larvae carried more than one egg of the parasitoid, thereby showing that the death of the host larva was caused due to excess deposition of eggs. The early first instar larva of *O. arenosella* is very small and if parasitised for the second time, it usually dies. The mortality rate is increased when 1 to 2 days old first instar host larvae are provided to the parasitoid. When ten females of this parasitoid are introduced into the oviposition tube containing 50 such host larvae, the mortality rate of the host reached up to 14 per cent (Table 1).

TABLE 1. Effect of host-parasitoid ratio on the larval mortality of *Apanteles taragamae*.

Number of parasitoid females/50 host	No. parasitised after one day	No. of host died	% of larval morta- lity
1	28 (5.38)*	1 (1.41)	2
2	38 (6 24)	0 (1.00)	0
4	36 (6.08)	2 (1.73)	4
6	41 (6.48)	4 (2.23)	8
8	44 (7.70)	5 (2.44)	10
10	40 (6.40)	7 (2 82)	14

*Numbers in parentheses are converted values;

The female of *A. taragamae* prefers to lay eggs in the larvae concealed within the gallery rather than in the freely moving larvae kept outside the gallery (Table 2).

When naked II stage larvae are given as hosts, only 12% parasitism occurred. This showed that the major factor which induces the host searching behaviour is present in the larval gallery (silken thread

TABLE 2. Choice of *Apanteles taragamae* for oviposition.

Choice dis- cription of the host larva	number of re- plicate	number of host given in each set	total no of larvae para- sitised	% of para- sitism after one hour
Freely mov- ing larva	10	5	6	12
Confined in the larval gallery	10	5	34	68

or the frass) produced by the larva. When samples of frass collected from different instar insects (glued separately to one square cm filter papers) are placed in specimen tubes carrying the female insects, they responded to the frass by exhibiting searching movements using their antennae and ovipositors. When the number of successful contacts leading to ovipositional probing with the frass containing filter paper in 10 minutes was counted, the maximum response (76.33%) was obtained with that containing the second instar frass, and minimum (36.25%) with the 5th instar frass. Thus the first, second and third instar larval frass produced higher host searching response in the parasitoid (above 60%) in comparison to the frass of the fourth or even fifth instars, which elicited only just about 30% contacts leading to ovipositional probing (Table 3).

Observations have indicated that the parasitoid shows only a weak response towards the old galleries of the host. When three categories of the host galleries *viz.*, fresh gallery (made by the second instar larvae), old gallery (more than one year old) and treated gallery (washed in

TABLE 3. Choice description of female *Apanteles taragamae* to the frass of different instars of *Opisina arenosella*.

Choice description (5 instars of *O. arenosella*)	number of replicate	Average percentage of contacts with the filter paper leading to ovipositional behaviour in 10 minutes
I instar	8	70.48 ± 6.5
II instar	8	76.33 ± 7.2
III instar	8	61.04 ± 8.1
IV instar	6	48.33 ± 5.0
V instar	6	36.25 ± 9.4

hexane and subsequently in alcohol and water) are given to the female parasitoids, a maximum response of 76.33% (contacts leading to successful ovipositional probing) was obtained with fresh gallery woven by II instar host larva. For old gallery the response was only 34.37% and with hexane washed one it gave only 25%. Generally, the ovipositing females have a shorter life span than that of the non-ovipositing ones with all food regimes supplied.

3. Sex ratio

Apanteles taragamae exhibits arrhenotokous parthenogenesis, the unfertilized females producing only males. The sex-ratio of the parasitoid is found to fluctuate and the data obtained from the field collections from September 1981 to January 1985 is given in Table 4. The male–female ratio varied from 1 : 1 to 2 : 3, the female always showing a higher proportion.

4. Developmental biology (Figs. 1 and 2)

The egg of *A. taragamae* is spindle shaped with a length of 0.42 ± 0.02 mm and a width of 0.052 mm. It is translucent white in colour and has slightly tapering ends. The chorion of egg is smooth without any sculptures. The egg bears a small peduncle at one end, while the other end is slightly broader. The shape of the egg dissected from the ovary and that taken out from the host larva differs considerably. The latter appears swollen probably due to the absorption

TABLE 4. Sex-ratio of *Apanteles taragame* from 1981 to 1985 collections.

Locality	collection	no. of pest larvae collected	no. of ♀ parasitoid emerged	no. of ♂ parasitoid emerged	sex ratio (♂ : ♀)
Kappad	81 Sept. to 82 September	826	24	13	2 : 3.68
Badagara	83 April to 84 February	620	29	22	2 : 3.2
Tellicherry	82 Sept., 83 Feb., March, Sept., Dec., 84, Feb., April, Sept., Dec.	2450	86	78	2 : 2.2
Elathoor	85 January	650	22	14	2 : 3.4
	Total	4606	166	130	10:15.78 (2:3)
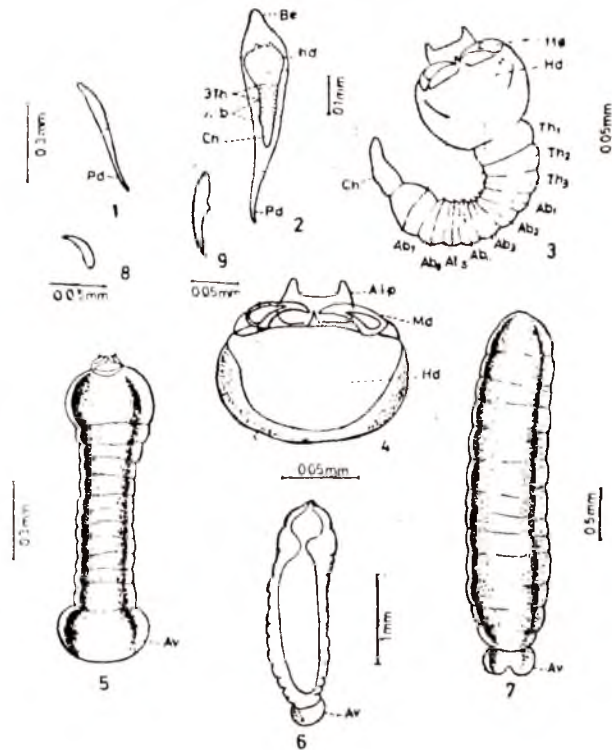
Fig. 1. Immature stages of *Apanteles taragamae*

1. Egg immediately after deposition; 2. Egg at 20 hours of incubation; 3. First instar larva; 4. Head capsule of the first instar larva; 5. Early second instar larva; 6. Second instar larva; 7. Third instar larva; 8. Mandible of the first instar larva; 9. Mandible of the second instar larva.

ABBREVATIONS : Ab—Abdominal segment; Alp—Anterolateral process; Av—Anal vesicle; Be—Broad end; Ch—Caudal horn; Hd—Head; Md—Mandible; Pd—Peduncle; Th—Thorax.

of the host body fluid. Dissection of the parasitised host larva during different seasons showed that the incubation time of the egg varies considerably depending upon the prevailing atmospheric temperature. In the hot months of March, April and May the eggs hatched within 18—24 (22 ± 2) hours of incubation, while during June to February it takes 20—35 (27 ± 3) hours. The incubation time does not vary depending upon the instars of the host in which the egg is laid.

Apanteles taragamae has three larval stages, which differ from each other in the shape and size of their body, in the dimensions of their head capsule and mandibles and also in their internal anatomy.

The first instar larva is mandibulate type. It is translucent white in colour and is found to float freely in the haemocoel of the host body. The larva is formed of a well developed head, 3—thoracic and 7 abdominal segments. The last abdominal segment bears a caudal
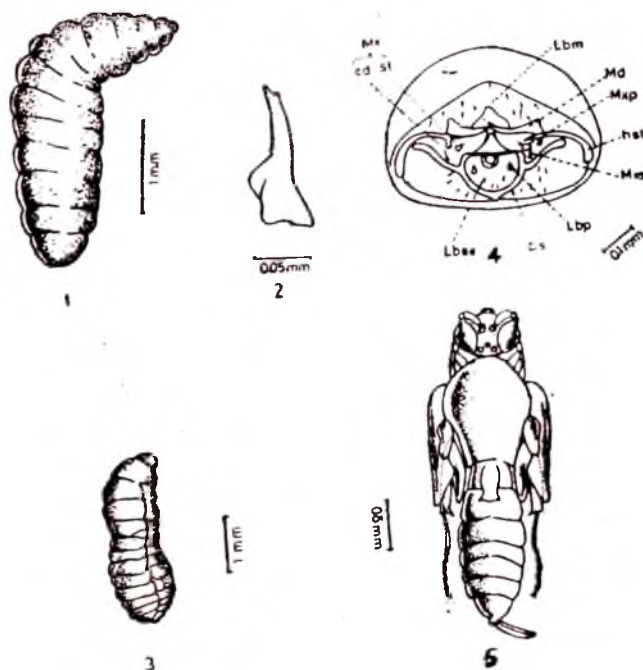
Fig. 2. Immature stages of *Apanteles taragamae.*

1. Third instar larva; 2. Third instar mandible; 3. Prepua; 4. Head capsule of the third instar larva; 5. Pupa.

ABBREVIATIONS : Cd—Cardo; Hast—Hypostomal selerome; Lbm—Labrum; Lbp—Lbabial selerome; Lbse—Labial seta; Md—Mandible; Mx—Maxilla; Mxp—Maxillary palp; Mxs—Maxillary seta; St—Stipes.

horn. The larva soon after eclosion measures 0.275 ± 0.02 mm in length' with a maximum width of 0.08 mm, seen in the head region. The head is somewhat oval in outline, with a faint cross line at the posterior side. The head capsule of the first instar measures 0.11 mm in length and 0.08 mm in width. The mandible measures 0.045 ± 0.01 mm in length with a maximum width of 0.015 ± 0.002 mm at its base. From the 5th day onwards the caudal horn regresses in size and soon becomes replaced by the enlarging anal vesicle.

The appearance of the second instar in the culture of the parasitised hosts varies, and depends mainly on the nature of the host larvae. Generally, during hot months, the stage is reached on the 7th or 8th day after oviposition, but it may well extend upto 12 or 13 days after oviposition, if the prevailing temparature is low. The second instar larva is opaque white in colour. It has a well developed anal vesicle at the posterior end. The body which is slightly flattened dorsoventrally consists of a very small head and 13 well developed body segments. The larva measures 1.5 to 2 mm in length. The mandibles are sickle shaped and measures 0.09 ± 0.02 mm in length, with 0.02 mm width at its base.

The third instar larva appears 8 to 10 days after oviposition and its duration varies from 1.5 to 2.5 days. The larva at this stage is typically hymenopteriform with a head and 13 body segments. The anal vesicle decreases in size with the development of the larva, to form a bilobed structure and finally disappears completely. At this stage the third instar larva measures 3.5 ± 0.4 mm in length with a maximum width of 0.8 ± 0.2 mm at its middle.

The third instar larva voids out its meconium and transforms itself into a prepupa. The prepupa is almost similar to the final instar except that it shows slight constriction between the thorax and abdomen. It measures 3.25 mm in length and 0.8 to 1 mm in width. The period lasts for 20 to 36 hours. The pupa is of exarate type and appears 10 to 13 days after oviposition. The whole development of the pupa is completed in about 6 days.

The shortest duration required by the parasitoid to complete the development from egg to adult has been found to be 15 days. This occurs in hot months, whereas in cold wheather the parasitoid takes 24 days to complete its immature stages.

DISCUSSION

Coconut caterpillar has been parasitised by many groups of insect parasitoids during its different stages of growth. Among the braconid group, *Apanteles taragamae* attacks the early larval stages of the pest. Mating behaviour of *A. taragamae* is found to be almost similar to the pattern reported in the case of other braconids and ichneumonids (FINK, 1926; BOUSCH & BAERWALD, 1967; VINSON, 1972; OBARA & KITANO, 1974; TAGAWA,

1977; WESELOH, 1977). Unmated females remain receptive throughout its adult life. This according to WESELOA (1977) is probably due to the pheromone produced in appreciable quantities throughout their adult life and possibly even during the pupal stage, as TAGAWA (1977) found in the case of *Apanteles glomeratus* (L.).

The females of *A. taragamae* are attracted towards areas containing the larval frass of the pest. The chemical substances which induces host searching behaviour is presumed to be present in the larval frass. LAING (1937) indicated that the parasite *Alysia manducator* and *Mormoniella vitripennis* Walk. were attracted to an environment by the quality of t e environment itself, independent of the presence of a host on a leaf. Visual stimuli are not so important in *A. taragamae*, as chemical stimulus serves as the prime factor in host location, followed by mechanical stimulus (vibrating movement of the gallery). Superparasitism reduces the efficiency of the primary parasitoid as reported in a number of braconid parasitoids, like *Chelonus blackburni* Cameron (VARMA & MANGAT, 1984). In *A. targamae* however the rate of suserparasitism is rather negligible.

The eggs of *Apanteles taragamae* laid in the haemocoel of the host are slightly bigger than their original size before deposition. This increase in size could be due to the absorption of host fluids by the developing embryo (CARDONA & OATMAN, 1971). If 2 or 3 eggs are laid in the same host body, all of them hatch into first instar larva, however only one develops into adult. ALLEN (1958) reported that some species of *Apanteles* are cannibalistic in their first instar stage. According to CLAUSEN (1940), the caudal appendage is a modification of last abdominal

segment. According to GILMORE (1938) it functions as an excretory organ while certain authors attributed respiratory functions to it (THROPE, 1932; NARAYANAN *et al.*, 1956).

The final instar larva of *A. taragamae* emerges from the host by peristaltic movement, as noted by CUSHMAN (1918) in *A. congregatus* Say. After emergence the third instar larva has been found to feed on the remaining part of the host larva, leaving its integument and head capsule. But some species of *Apanteles*, like *A. marginiventris*, was never found to feed on the host after emergence (BOILING & PITRE, 1970).

The duration of immature stages of the members of Microgastrinae varies. *A. taragamae* completes its life stage in 15 to 18 days, the average being 17 days. However the upper limit can be extended upto 40 days.

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STUDIES ON PUPAL METABOLISM IN *CATOPSILIA CROCALE* (LEPIDOPTERA : PIERIDAE)

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Pupal metabolism was studied in the butterfly *Catopsilia crocale* in relation to rearing temperature and food ration. While ration did not alter the pupal duration, temperature influenced it significantly. Metabolic rate during pupation (metamorphic metabolic rate) increased with increasing temperature and decreasing ration. On the contrary pupal efficiency was higher at low temperature and low ration. An inverse relationship became apparent between metabolic rate of larva (Mr) and metamorphic metabolic rate (MMr) of pupa.

(Key words: pupal metabolism, *Catopsilia crocale,* rearing temperature, food ration, pupation, temperature)

INTRODUCTION

In lepidopterans, pupal stage is a specialised transitional stage, which provides an opportunity for the divergence of larva and adult, and permits them to exploit different habitats. During the feeding larval period, considerable amount of the energy is stored to tide over the non-feeding pupae and in some cases the adults too.

The pattern of allocation of stored energy to pupal and adult life varies among the lepidopterans (e.g. Moon & Carefoot, 1972; Mackey, 1978). Studies on this line revealed that several factors such as sex (Mackey, 1978), temperature (Muthukrishnan, 1980) and food availability (Mathavan & Muthukrishnan, 1976) influence pupal efficiency. However, studies on rates of pupal metabolism in lepidopterans are scanty. The present study is attempted to analyse the effect of temperature and food ration on the rate and efficiency of pupal metabolism of the butterfly, *Catopsilia crocale.*

MATERIALS AND METHOD

First instar larvae of *C. crocale* collected from the field were maintained at 5 different temperatures viz., 17, 22, 27, 32 and $37 \pm 1°C$ in BOD incubators and offered *ad libitum* food. On attaining III instar the larvae reared in each temperature were sorted out into 4 groups each consisting of five replicates, Group I was offered a food ration of 25% and groups II, III, and IV were offered 50%, 75% and 100% *(ad libitum)* ration feeding. Ration levels for the respective instars were fixed considering the mean daily food consumption of the larva fed *ad libitum* at the corresponding temperature as 100%. Fresh leaves of normal host plant *Cassia alata* served as food for the larvae.

Calorific content of oven-dried samples were determined using a Parr 1411 semi-micro bomb calorimeter. The following formulae were used to calculate the different parameters of pupal metabolism.

$$\text{Energy expended on metamorphic metabolism (MM)} = \text{Energy content of pupa (Joules)} - \text{Energy content of imago (J)}.$$

$$\text{Metamorphic Metabolic rate (MMr) (J/g live wt/day)} = \frac{\text{MM(J)}}{\text{wt. of pupa} \times \text{pupa duration (day)}}$$

$$\text{Pupal efficiency (\%)} = \frac{\text{Energy content of imago (J)}}{\text{Energy content of pupal (J)}} \times 100$$

RESULTS

Duration: While temperature remarkably influenced the pupal duration, ration did not alter the duration. Individuals reared at 17, 22, 27, 32 and 37°C required 14, 8, 7, 6 and 5 days respectively to complete the pupal period in all the ration levels.

Water and energy content: Water content of the terminal larva ranged from 79% at 37°C to 82% at 17°C. Similarly, water content of imago fluctuated between 68 and 71% at these temperatures. Such a wide variation in water content due to ration feeding was not apparent (Table 1).

Calorific density, in other words the energy concentration (KJ/g dry weight) of the terminal larva, pupa and imago was estimated to understand the pattern of energy utilisation during the pupal period. On an average energy content of terminal larva was 23.43 KJ/g dry weight and it decreased to 22.65 KJ/g dry weight in the freshly emerged adult.

At any tested temperature, energy content of pupa and imago increased with increasing ration (Table 2). Energy

TABLE 1. Effect of temperature and ration on water (%) and energy content (kJ/g dry weight) of terminal larva and imago of *C. crocale.*

	Ration %	Temperature (°C)				
		17	22	27	32	37
		Terminal larva				
Water	25	82.45	82.02	81.61	80.51	79.12
content	50	82.40	82.15	81.54	80.34	79.05
	75	82.35	81.89	81.20	80.52	79.04
	100	82.00	81.52	81.05	80.26	78.91
Energy	25	22.58	22.85	23.28	23.64	23.60
content	50	22.95	23.15	23.20	23 65	23.52
	75	23.00	23.05	23.35	23.80	23.70
	100	23 00	23.20	23.48	23.95	23.90
		Imago				
Water	25	71.30	71.00	69.92	69.34	68.61
content	50	71.05	70.80	69.51	69.09	68.25
	75	71.00	70.50	69 52	69.46	68.08
	100	70.80	70.50	69.45	69.02	68.02
Energy	25	21.69	21.95	22.60	22.78	22.70
content	50	21.80	22.00	22.65	22.70	22.65
	75	21.90	22.08	22 65	22.72	22.70
	100	22.01	22.05	22.68	22.75	22.70

TABLE 2. Energy content (J/individual) of pupa imago (in parenthesis) as functions of ration and temperature.

Temper-ature (°C)	25	50	Ration (%) 75	100
17	870±51 (485±42)	1625±66 (930±51)	2029±80 (1220±68)	2946±96 (1825±87)
22	845±38 (460±29)	1508±44 (848±25)	1955±45 (1125±15)	2518±60 (1486±21)
27	876±44 (465±22)	1454±52 (790±29)	1780±39 (980±34)	2177±70 (1247±35)
32	940±43 (485±33)	1425±63 (760±42)	1740±48 (942±49)	2083±51 (1181±53)
37	840±44 (420±24)	1251±61 (650±36)	1960±64 (895±40)	1905±58 (1034±54)

TABLE 3. Energy spent (J/individual) on pupal metabolism by *C. crocale* as functions of ration and temperature.

Temper-ature (°C)	25	Ration (%) 50	75	100
17	385 ± 24.10	695 ± 30	839 ± 29	1121 ± 42
22	385 ± 4.5	660 ± 15	830 ± 20	1032 ± 24
27	411 ± 17	664 ± 23	800 ± 28	930 ± 37
32	455 ± 9.0	665 ± 24	798 ± 13	902 ± 20
37	420 ± 14	601 ± 25	795 ± 36	871 ± 41

TABLE 4. Metamorphic metabolic rate (MMr; J/g/day) of *C. crocale* as functions of ration and temperature.

Temer-ature (°C)	25	Ration (%) 50	75	100
17	145.5 ± 4.5	139.0 ± 5.2	133.0 ± 8.6	125.1 ± 6.2
22	238.1 ± 4.5	226.0 ± 13.2	219.6 ± 3.8	211.5 ± 5.2
27	315.7 ± 8.2	306.0 ± 4.5	300.8 ± 12.2	286.0 ± 4.5
32	446.1 ± 13.2	403.0 ± 8.6	394.7 ± 5.0	372.0 ± 15.6
37	521.7 ± 12.1	494.0 ± 5.6	484.8 ± 14.0	469.0 ± 5.2

TABLE 5. Analysis of variance for the effect of temperature and ration on the metamorphic metabolic rate of *C. crocale*.

Source	SS	DF	MS	F	P
Total	1464.45	59	—	—	—
Between rations	196.50	3	65.50	2.99	$p > 0.05$
Between temperatures	390.65	4	97.36	4.45	$p < 0.005$
Interaction	730.00	12	60.88	2.78	$p > 0.05$
Error	877.30	40	21.93	—	—

content of the pupa as well as the imago was remarkably low in the individuals reared at high temperatures. For instance, fed *ad libitum*, individuals reared at 17, 22, 27, 32 and 37°C attained the energy content equivalent to 2946, 2518, 2177, 2083 and 1905 J/individual, respectively in the freshly formed pupa.

Metamorphic metabolism: Pupa from the low ration levels spent limited amount of energy on metabolism (J / individual) and those at high rations spared considerably more energy for metabolism. These values can be obtained by subtracting the energy content of imago from the pupa (Table 3). Barring *ad libitum* fed individuals, energy spent on metamorphic metabolism at 25, 50 and 75% ration fed group was not significantly altered by temperature ($P > 0.05$).

Table 4 revealed that at any ¦tested temperature, the metamorphic metabolic rate (MMr) of the test individual was higher in the 25% ration group than those at other rations. At all the tested rations, rate of metamorphic metabolism increased with increasing temparature. Pupa obtained from individuals receiving 50% ration expended as much as 139, 226, 306, 403 and 494 J / g / day at 17, 22, 27, 32

and 37°C, respectively. Analysis of variance of MMr for individuals reared at different temparature and ration revealed that while temperature significantly influenced the MMr ($P < 0.05$), ration did not influence it significantly ($P > 0.05$) (Table 5).

Figure 1 represents the MMr of different ration group at a particular temperature regressed against the respective
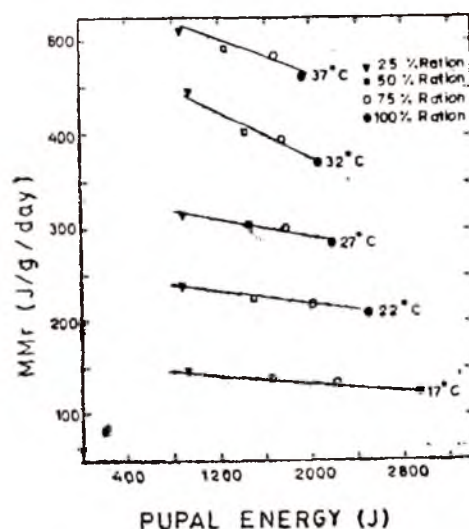

Figure 1. Metamorphic metabolic rate as a function of pupal energy of *C. crocale*.

TABLE 6. Effect of temperature and ration on the pupal efficiency (%) of *C. crocale*.

Temper-ature (°C)	Ration (%)			
	25	50	75	100
17	55.75 ± 0.80	57.23 ± 0.85	59.25 ± 0.92	61.95 ± 0.75
22	54.40 ± 0.40	56.20 ± 0.35	57.50 ± 0.54	59.02 ± 0'48
27	53.10 ± 0.20	54.30 ± 0.72	55.10 ± 0.65	57.30 ± 0'58
32	51.60 ± 0.70	53.30 ± 0,82	54.10 ± 0.65	56.70 ± 0.45
37	50.00 ± 0.40	52.00 ± 0.65	53.00 ± 0.45	54.30 ± 0.30

TABLE 7. Analysis of variance for the effect of temperature and ration on the pupal efficiency of *C. crocale*.

Source	SS	Df	MS	F	P
Total	1145.69	59	—	—	—
Between rations	185.08	3	61.69	3.86	$p < 0.01$
Between temperatures	320.48	4	80.12	5.01	$p < 0.005$
Interaction	517.83	12	43.15	2.70	$p > 0.05$
Errror	640.13	40	16.00	—	—

pupal energy. It is clear from the figure that MMr shifted from an average of 145—125 J / g / day at 17°C to 522—469 J / g / day at 37°C irrespective of ration levels. Pupa with an energy content of 1200 J expended about 130 J / g / day on metabolism at 17°C; whereas a similar size pupa at 37°C expended energy at the rate of 500 J / g / day on pupal metabolism. This results in the production of larger pupa and imago at lower temperatures than at higher temperatures.

Pupal efficiency: The efficiency with which pupal energy is transferred into adult energy is termed as pupal efficiency (MATHAVAN & MUTHUKRISHNAN, 1976). Table 6 clearly revealed that pupal efficiency was significantly low in the restricted ration groups than in the *ad libitum* groups ($P < 0.05$). At 32°C, the efficiency was 56.7, 54.1, 53.3 and 51.6% in the individuals receiving 100, 75, 50 and 25% ration, respectively. Similarly, at any tested ration level, temperature remarkably influenced the pupal efficiency; it was maximum at low temperature and minimum at high temperatare. Analysis of variance of the data of pupal efficiency revealed that temperature more significantly influenced the pupal efficiency ($P < 0.005$) than ration ($P < 0.01$) (Table 7).

DISCUSSION

Pupal duration, as non-functional to ration level revealed that once the pupa is formed at any tested temperature, the
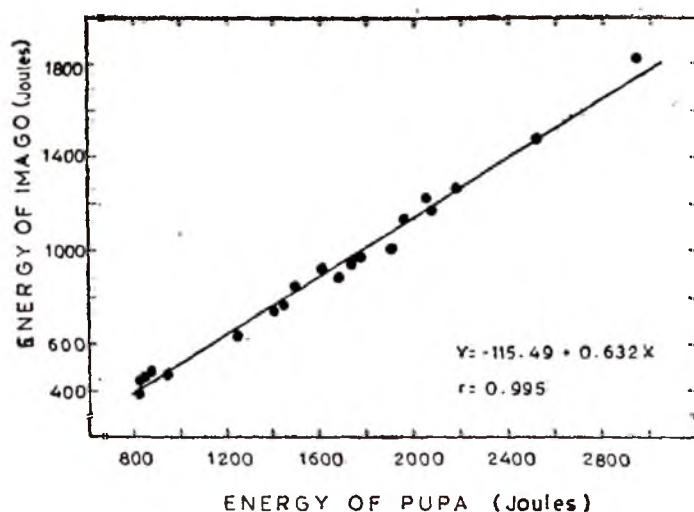
Figure 2. Energy content of pupa as a function of the energy content of imago,

rate of transformation of pupa into adult progressed at a constant rate. The miniature pupa at 25% ration or the largest pupa at 100% ration required the same duration for the histolysis of the pupal issues and the histogenesis of the imaginal tissue.

Relationship between energy content of the pupa and energy content of the imago was represented in Fig. 2. Irrespective of temperature and ration levels, the energy content of the imago depends on the energy content of the pupa. It is possible to predict the energy content of freshly emerged imago from the pupal energy since the correlation coefficient was highly significant (r = 0.995).

The energy content of pupa holds an inverse relation to MMr and the former determines the metabolic level of the latter. Understandably, the larger the weight of the pupa lower its metabolic rate during pupal period. To produce 1 J adult tissue, the pupa at 17°C had to expend 0.79, 0.75, 0.69 or 0.61 J on metabolism at 25, 50, 75 and 100% ration

level; corresponding values at 37°C were 1.0, 0.91, 0.89 or 0.84 J. This analysis suggests that for a unit weight of pupal transformation into imago, *C. crocale* requires more energy at high temperature and low ration.

Recalculated values of MOON & CAREFOOT (1972) showed that the greater wax moth *Galleria mellonella* required about 420 J / g / day during matemorphosis. This value is close to the value of the *ad libitum* fed *C. crocale* reared at 32°C (440 J/g/day).

When MMr is correlated with the larval metabolic rate (Mr) at the respective ration and temperature (data from CHRISTOPHER, 1983) an inversely related correlation was obtained (Fig. 3). Exposed to different temperatures and rations, the Mr of the larvae ranged between 500 and 3200 J/g/day. In other words the larvae are capable of elevating its Mr by about 6 times higher than its lowest level. On the other hand, the pharate adult could elevate MMr by about 4 times. The larvae with high Mr expend less energy
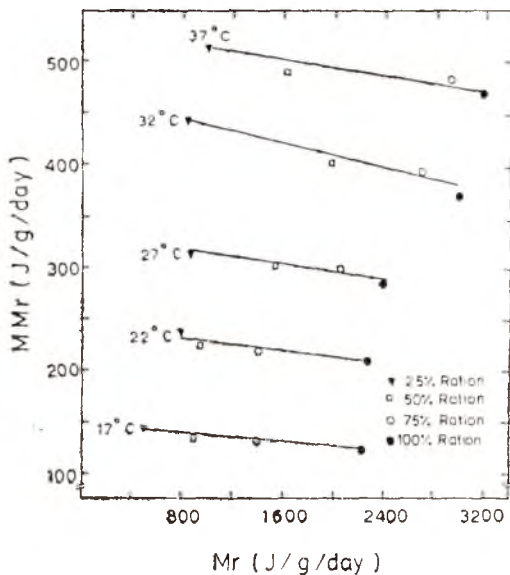
Figure 3. Metamorphic metabolic rate as a function of larval metabolic rate.

on MMr than the one with low larval Mr. For instance, the larvae at 37°C with a metabolic rate (Mr) of 1000 J/g/day spend about 515 J/g/day on MMr. At the same temperature, larvae spending about 3000 J/g/day on Mr, allocate only about 470 J/g/day on MMr. Thus, it appears that the larvae tend to 'bargain' a sort of compensation between high larval Mr and low pupal MMr. Such a compensatory mechanism has also been reported by MARIAN (1982) for metamorphosing tadpoles of *Rana tigrina*.

The efficiency with which pupal tissues are converted into imaginal substance ranged between 50 and 62% for *C. crocale* exposed to different rations and temperatures. An intensive survey of the literature showed that the value ranges between 31% (*Nemeritis cenescens*: HOWELL & FISHER, 1977) and 51% (*Melittobia* sp. MARIAN et al., 1982) for parasitic hymenopterans, 35 and 56% in the parasitic

dipteran *Sarcophaga banksi* receiving different rations (PRAKASH & PANDIAN, 1978), 35% for the moth *Cyclophragma leucosticta* (MACKEY, 1978) and 54% for *G. mollonella* (MOON & CAREFOOT, 1972). Pupal efficiency of *Achaea janata* and exposed to different rations temperature ranged between 45 and 62% (MUTHUKRISHNAN, 1980). Similarly *Danaus chrysippus* (MATHAVAN & MUTHUKRISHNAN, 1976) receiving restricted rations lowered the pupal efficiency. For want of more information, it is difficult to identify the factor(s) responsible for the wide variations in pupal efficiency. However, the results obtained in the present study clearly indicate that both remperature and ration play an important role in the regulation of pupal efficiency.

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SOME OBSERVATIONS ON THE FORAGING GALLERIES AND FORAGING ACTIVITY OF THE TERMITE, *ODONTOTERMES FEAE* WASMANN (ISOPTERA : TERMITIDAE)

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The foraging population from the covered runways on *Eucalyptus longifolia,* foraging galleries and foraging activity of the termite, *Odontorermes feae* have been studied. The population of foragers in 10^2 sq cm area varied from 5—36. Only one main gallery was traced from the infested eucalyptus tree to the nest and its length was 31m. Twelve branching galleries ramified from the main gallery. The active foraging was observed in the galleries at the temperature of $17°—25°C$ and it decreased as the temperature increased from $25°—28°C$. The activity completely ceased when the temperature was above $28°C$.

(Key words : foraging galleries, foraging activity, population, temperature, *Odontotermes feae)*

INTRODUCTION

Most of the termites construct a system of galleries and covered runways on the respective food plants for safe foraging (WOOD, 1978). The extent of foraging galleries of termites has been studied in *Macrotermes subhyalinus* (WOOD & OHIAGU, 1976), *Odontotermes wallonensis* (VEERANNA & BASALINGAPPA, 1981). The foraging activity of several species of termites during dial period and different seasons of the year has also been studied in *Trinervitermes geminatus, M. subhyalinus* (OHIAGU & WOOD, 1976), and in *O. wallonensis* (VEERANNA & BASALINGAPXA, 1981). The present investigation was undertaken to reveal the foraging population, foraging galleries and foraging activity of *Odontotermes feae.*

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MATERIALS AND METHOD

The subterranean mound nest *O. feae* and infested eucalyptus trees in the vicinity of the Karnataka University Cumpus, Dharwad. India, were the material for the study. Foraging population was studied from ten *Fucalyptus longifolia* trees by actually counting the termites in 10^2 sq cm area and total population of complete covered runways on each tree was calculated. Foraging galleries were traced from the infested eucalyptus tree to the mound nest and their measurements were recorded.

RESULTS

The foraging population from the covered runways on *Eucalyptus longifolia* and measurements of the foraging galleries of *O. feae* are given in the Tables 1 & 2.

Only one main foraging gallery was traced from the infested eucalyptus tree to the nest. Twelve branching galleries ramified from the main gallery (Fig. 1). The length of the main gallery from the nest to the infested tree was 31 m

TABLE 1. Foraging population of the termite, *Odontermes feae* Wasmann from the covered runways on *Eucalyptus longifolia* (10 replications.)

Number of workers per 10² sq cm area.	Number of soldiers per 10² sq cm area	Number of workers from the entire covered runways	No. of soldiers from the entire covered runways	Total No. of termites from the entire covered runways	Percentage of		Total area of the covered runways from the encalyptus tree (sq cm)
					workers	soldiers	
Range 4–32	1–5	230–2527	16–193	247–2595	68.50–97.70	2.30–31.50	1952–11279
Mean 12.36	1.46	800.30	59.40	859.80	90.57	9.44	6183.30

TABLE 2. Measurements of the foraging galleries of the termite, *Odontotermes feae* Wasmann (14 replications).

Depth of the main gallery (cm)	Width of the main gallery (cm)	Height of the main gallery (cm)	Depth of the branching gallery (cm)	Width of the branching gallery (cm)	Height of the branching gallery (cm)
Range 10—65	2.5—6.5	1.4—4.0	5—40	1.5—3.5	1.2—2.5
Mean 29.38	4.7	2.5	20.92	2.56	1.96

and the length of branching galleries was not traced completely. It has been observed that the wall of the galleries was finely plastered by foragers using fine clay soil with saliva and excreta. The height and width of the main gallery at the nest was 4.0 cm and 6.5 cm and at the infested eucalyptus tree was 1.4 cm and 2.5 cm respectively. The foraging gallery was bow shaped; roof was arch like and floor was plane and smooth. Eight waiting rooms were found along with main gallery and five of them were housing the fungus–garden. The workers and soldiers of *Odontotermes assmuthi* and *Microcerotermes* sp. were also observed in the galleries of this species.

The foraging activity of workers and soldiers was recorded from 08.00 to 11.00 h. The foraging activity decreased in the galleries as temperature increases from 25°—28°C and activity completely ceased when the temperature of above 28°C. The temperature in the foraging galleries at the time of active foraging was 17°—25°C. It has been observed that the population of foragers was more in main gallery compared to branching galleries.

DISCUSSION

In Macrotermitinae, the foraging galleries were running to the extent of 30 to 40 m from the central part of the nest to the food source, in Africa (LEE & WOOD, 1971). According to WATSON (cited by WOOD, 1978) the subterranean galleries of *Drapanotermes* sp. extended up to 30 m from the nest.
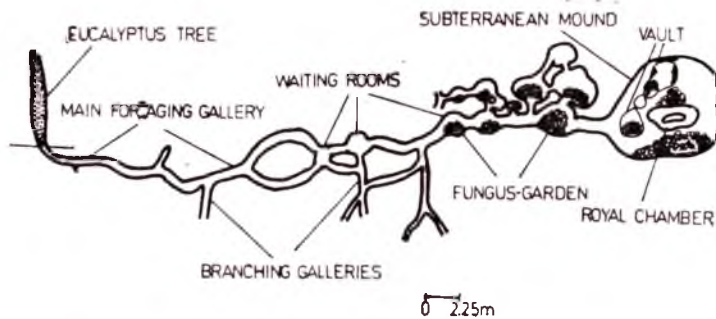
Fig. 1. Diagramatic sketch of the foraging gallery from the infested eucalyptus tree to the subterranean nest of *O. feae*.

GREAVES (1962) observed in two nests of *Coptotermes acinaciformis* that the foraging galleries were 6 and 10 and their distance was about 48 m to the food source. The foraging galleries of *O. wallonensis* were found 3 to 5 and their distance ranged from 7 to 13 m from the nests to the food source. The depth of these galleries was 10 to 30 cm (VEERANNA & BASALINGAPPA, 1981). The present investigation revealed that only one main gallery was running up to the distance of 31 m from the subterranean nest to the infested eucalyptus tree. The depth of the main gallery ranged from 10 to 65 cm and that of branching galleries was 5 to 40 cm.

During the foraging activity of *Trinervitermes geminatus* it was found that foraging parties emerged twice during 24 h i. e., from 06.00 to 09.30 h and 16.30 to 18.30 h (OHIAGU & WOOD, 1976). *Hodotermes mossambicus* forage during day time only and it usally started when the temperature varied from 22° to 27° C (NEL, 1968). The foraging activity of *O. wallonensis* was observed in cool hours of the day throughout the dry months of the year and ceased at the temperature of above 27°C, inside the galleries (VEERANNA & BASALINGAPPA, 1981). In the present study, the foraging activity in the galleries of *O. feae* was found to decrease as temperature increases from 25° to 28°C and activity ceased above 28°C. The temperature in the galleries varied from 17° to 25°C. at the time of foraging.

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A RELIABLE EGG COUNT METHOD TO FIX ECONOMIC THRESHOLD LEVEL FOR SORGHUM SHOOTFLY *ATHERIGONA SOCCATA* ROND

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Pest control programmes should be based on economic threshold. In sorghum shootfly, *Atherigona soccata* Rond. economic threshold levels are fixed based on dead heart symptoms. The present investigations related the per cent plants with shootfly eggs and per cent plants with dead heart symptoms. The regression equations arrived were $y = -1.66 + 1.01 x$ for CSH 9 and $Y = -1.61 + 1.02 x$ for Co 26. This indicates that for every unit increase in plants laid with egg (one or more) an unit increase in dead heart could be expected. The side tillers produced by the affected plant also followed the same pattern

(Key wards : sorghum shootfly, *Atherigona soccata*, economic threshold, egg, dead heart, side tillers)

INTRODUCTION

The sorghum shootfly, *Atherigona soccata* Rond. is a major pest of sorghum in most parts of the Indian sub continent and in many parts of Africa. Integrated pest management strategies are being followed to tackle this pest. Successful IPM programme is based on economic thresholds of insect pest. Young (1981) reported these levels in shootfly in terms of 'dead heart' as 3.8–9.6 per cent for 'CSH 1', 3.4-8.5 per cent in 'CSH 5' and 5.9–15.00 per cent in 'Swarna'. All attempts made so far to work out the economic threshold level (ETL) were based only on 'dead heart' symptom. In the present study attempts were made to find out the relationship between plants with egg and plants with dead heart so that the ETL can be fixed based on plants laid with eggs. Similar studies were also made on the side tillers.

MATERIALS AND METHOD

Six different times of sowing with weekly intervals were taken during Kharif 1986 with 'CO 26' variety and 'CSH 9' hybrid in a randomised block design replicated four times. As the distribution of eggs on plants is uneven (Delobel, 1981) twenty plants per replication were tagged at random as soon as the seedlings emerged and closely monitored for eggs which are white, cylindrical and usually laid on the lower surface of leaf. The plants were also monitored for dead heart subsequently. Regression equation was worked out to find out the relationship between the plants with egg and plants showing dead heart as per the method suggested by Snedecor & Cochran (1967).

The side tillers emerging from the affected plants were also observed for egg subsequently for dead heart.

RESULTS AND DISCUSSION

The infestation levels recorded during the experimental period ranged from 12.5 to 91.25 per cent dead heart in 'CSH 9' and

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Table 1. Distribution of eggs of shootfly and occurrence of dead heart symptom.

Dates of sowing	mean No. of eggs / plant		per cent plants showing eggs		percent dead hearts based on entire population	
	CSH 9	CO 26	CSH 9	CO 26	CSH 9	CO 26
23-6-86	1.00	1.00	13.75	11.25	12.50	10.00
30-6 86	1.23	1.01	28.75	21.75	27.50	10.25
7-7-86	1.23	1.01	25.00	18.76	22.50	17.50
14-7-86	2.00	1.67	46.25	26.25	45.00	26.25
21-7-86	2.01	1.67	42.50	37.50	41.25	36.25
29-7-86	2 01	2.58	91.25	53.75	91.25	53.75

Regression equation : 'CSH 9' : $Y = -1.66^{NS} + 1.01X^{**}$ 'CO 26' : $1.61^{NS} + 1.02X^{**}$
** Highly significant (1% level).

Table 2. Distribution of eggs of shootfly and occurrence of dead heart symptom in side tillers.

Date of sowing	Total No. of affected plants		Total No. of sidetillers		Total No. of side tillers showing egg		Total No. of side tillers showing dead heart symptom	
	CSH 9	CO 26	CSH 9	CO 26	CSH 9	CO 26	CSH 9	CO 26
	(mean)							
23-6-86	10	8	25	17	25	14	25	12
20-6-86	22	15	46	44	42	38	41	29
7-7-86	18	14	45	34	45	26	45	24
14-7-86	36	21	78	51	76	33	76	33
21-7-86	33	29	70	74	69	58	66	58
29-7-86	72	43	196	96	146	88	146	88
Total	191	130	410	316	403	257	399	244
			2.15[a]	2.43[a]	98.29[b]	81.23[b]	97.73[c]	77.20[c]

[a] denotes mean tillers / plant; [b] denotes percentage of tillers showing egg (one or more);
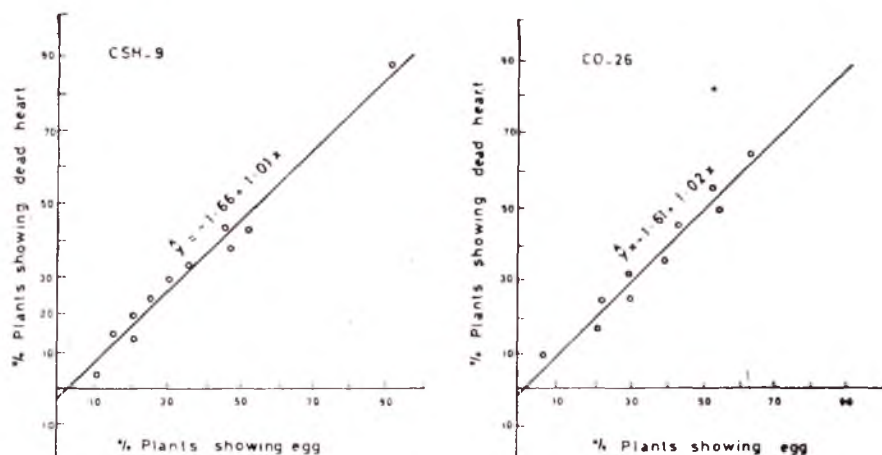[c] denotes percentage of tillers showing dead heart symptom.

Fig. 1. Relation between plants showing eggs and dead heart symptom.

10.0 to 53.75 per cent in 'CO 26' (Table 1). Late sown crops recorded maximum damage due to the pest build up. Almost all the plants on which eggs were laid showed dead heart symptom. Further the number of egg per plant was normally one, though at later sowing due to heavy population build up, 2 eggs per plant were observed. YOUNG (1981) reported oviposition deterring pheromone deposited by female on (or) around the egg during (or) immedtately after oviposition which prevents other flies laying eggs. However, depending on the environment the pheromone may get neutralised. Even in the presence of more than one egg in a single plant, only a single first instar larva develops while other perish as successful migration between plants is very unlikely (DELOBEL, 1981). A simple regression equation was worked out to find out the relationship between plant showing egg and dead heart symptom (Fig). The equations were $Y = -1.66 + 1.01X$ for 'CSH 9' and $Y = -1.61 + 1.02X$ for 'CO 26'. The intercepts (i.e. –1.66 and –1.61) were found to be statistically insignificant. The observation made in the side tillers

are presented in Table 2. Mean number of side tillers observed per plant varied from 2.15 to 2.43. Almost all the side tillers of both 'CSH 9' and 'CO 26' laid with eggs showed dead heart symptom.

The present investigations reveal that for every unit increase in plants with egg an unit increase in dead heart symptom can be expected. Singh and JOTWANI (1980) established a direct correlation between eggs and dead heart in sorghum shootfly. YOUNG (1981) while reviewing fifty five years of research on shootfly, reported that only few parasites are available for shootfly and that too their effect seemed to be minimal. UNNITHAN (1985) while studying the environmental factors stated that the temperature range of 23.9°C—33.0°C had a significant role in rapid multiplication of shoot. Since outside temperature falls within this range normally no adverse temperature effect can be expected. Further the intercept (a = –1.61) was also found to be statistically insignificant. ANONYMOUS (1986) reported 10.00 per cent dead heart as ETL for sorghum shootfly which is widely

followed by the farmers and extension functionaries in IPM programme. From the present investigation it can be recommended that if 12 per cent of the plants show shootfly egg (one or more) a damage potential of 10 per cent dead heart formation can be expected.

Based on the fact that eggs take 24—48 h in hatching, this indication would be quite helpful in adopting plant protection measures effectively in advance than initiating action on the appearance of the 'dead hearts'. This will also affect the strategies in the IPM programme.

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DUSK BITING MOSQUITOES OF MANIPUR

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Biting-rate of mosquitoes during dusk-hour over human and bovine bait along with monthly variation for Manipur valley is presented. Some erratic observations about dusk-biting from hilly region are also included. During the study some 21 species from human and 22 species from bovine baits under 6 genera viz., *Aedes, Armigeres, Coquillettidia, Culex* and *Mansonia,* were noted

(Key words : dusk biting mosquitoes, Manipur)

INTRODUCTION

Mosquito biting not only annoys but also serves as means of transmission for some parasitic diseases like malaria and filaria, and viral diseases like Japanese encephalitis, dengue and chikungunya etc. The rate of mosquito biting over the human bait serves as an indicator for potentiality of disease transmission of the vector population present in the area. Similarly, the biting rate over bovine bait at one side diverts the vector population reducing the probability of disease transmission to human, but on the other hand it also serves as alternative means of survivability and multiplication of the population. Bovine feeding also facilitates the multiplication of pathogens in the mosquito from the animals serving as reservoirs. Biting rate at a particular time during different months serves as important parameter for the population responding to biting. The biting rate is a requisite pivotal information in the disease epidemiology.

In view of the above, present study was carried out taking one hour biting sample during dusk for the period October 1983 to September 1984 from human and bovine baits. Some errectic samples were also taken form hilly region of the state in order to find out any difference in hilly and valley fauna in relation to dusk biting.

MATERIALS AND METHODS

Fortnightly human and bovine bait collections during dusk for one hour were maintained for one year at Mantripukhri (785 m). For human bait, self-bait technique was applied (W H O, 1975), while for bovine bait a calf was used as a bait. Some erratic samples were also taken from the hilly region of the state using human and bovine baits. The mosquitoes collected were killed with ether and kept separately with date and locality record for identification. The specimens were identified with the help of BARRAUD (1934), CHRISTOPHERS (1933) and some more recent publications. During the work nomenclature was followed from KNIGHT & STONE (1977). The materials are now deposited in the collection of Entomology Research Unit, Department of Life Sciences, Manipur University, India.

OBSERVATIONS

During the study, dusk shifting in valley were observed from 4.30 P M to

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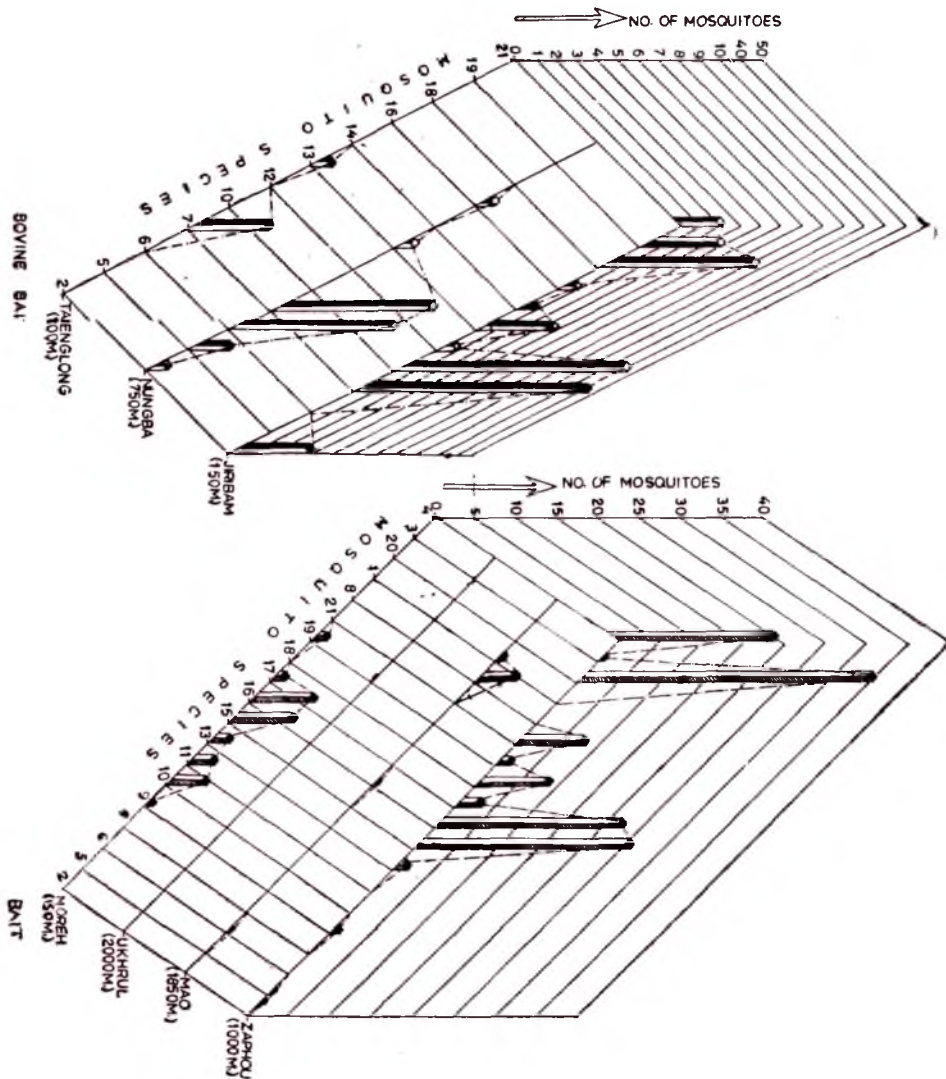
Fig. 1. Bait collection during evening (dusk) from some hilly localities of Manipur. Mosquito species: 1. *Anopheles crowfordi*; 2. *Anopheles nigerrimus*; 3. *Anopheles peditaeniatus*; 4. *Anopheles jeyporensis* var. *candidiensis*; 5. *Anopheles maculatus*; 6. *Anopheles maculatus* var. *willmori*; 7. *Anopheles vagus*; 8. *Aedes niveus* group; 9. *Aedes albopictus*; 10. *Armigerus subalbatus*; 11. *Culex bitaeniorhynchus*; 12. *Culex epidesmus*; 13. *Culex fuscocephala*; 14. *Culex gelidus* 15. *Culex quinquefasciatus*; 16. *Culex pseudovishnui*; 17. *Culex sinensis*; 18. *Cluex tritaeniorhynchus* 19. *Culex whitmorei*; 20. *Coquillettiidia crassipes*; 21. *Mansonia uniformis*.

6.15 P M. In this study 600 mosquitoes belonging to 21 species under 6 genera viz., *Anopheles, Aedes, Armigeres, Coquillettidia, Culex* and *Mansonia* were collected from human baits. More than 6 times of the mosquitoes collected from human baits were collected from bovine baits. The mosquitoes collected from bovine baits belongs to 22 species under 6 genera (Fig. 1). Except *Anopheles sinensis, A. subpictus* and *Mansonia annulifera* which were absent from human baits and *Aedes albopictus* and *A. splendidus* which were absent over the bovine bait, rest of the species were common to human and bovine baits.

The most prevalent human biters during dusk hour were *Mansonia indiana, Culex quinquefaciatus, Armigeres subalbatus, C. pseudovishnui, M. uniformis, C. fuscocephala* and *C. tritaeniorhynchus. A. vagus, C. fuscocephala, C. gelidus, C. pseudovishnui, A. nigerrimus, Ar. subalbatus, C. tritaeniorhynchus, M. uniformis* and *M. indiana* were recorded from bovine baits in a considerable number.

From the erratic, dusk hour human bait collections from some localities of the state viz., Moreh (150 m), Mao (1,850 m), Ukhrul (2,000m) and Zauphou 1,000m), total 19 species belonging to 6 genera viz. *Anopheles, Aedes, Armigeres, Coquillettidia, Culex* and *Mansonia* were collected (Fig. 2.) *A. maculatus* and its variety *willmorei, A. crawfordi, A. jeyporiensis* var. *candidiensis, Ae. niveus* group and *Coq. crassipes* were found in addition to the human biting species from valley.

The mosquitoes from bovine baits from erratic dusk hour collection from hilly egion localities viz. (Jiribam (150m), Nungba (750 m) and Tamenglon (1,200m) belongs to 12 species under 5 genera (Fig. 2.). Only *A. maculatus* its variety

willmorei and *C. epidesmus* were addition to the species feeding over bovine baits in valley.

A. nigerrimus biting over human baits were negligible, while it is 10.5% of the total population received over bovine baits.

Ar. subalbatus were about 13% of the total over the human baits and 7% over the bovine baits. With the comparison of human to bovine baits more than 3 times mosquitoes were collected from bovine baits.

C. fuscocephala were 7.5% of the total mosquitoes from human baits, while it was 17% from bovine baits. The mosquitoes received from bovine baits were about 15 times of the mosquitoes from human baits. *C. quinquefasciatus* were about 19% of the total mosquitoes from human baits, while it was only 0.7% over the bovine baits. About four times mosquitoes were collected from human baits than the bovine baits. This pronounced biting over human bait is of immense importance because the species is an important vector of filaria in the country. *C. psudevishnui* was noticed to be about 12% of the total mosquiees rcceeived from human as well as over bovine baits also. However, about seven times mosquitoes were colleced from bovine baits than the human baits. This result shows that though the species is more attracted to bovine bait but it is also an important component of the human biting fauna during dusk. *C. tritaeniorhynchus* was about 7% of the total mosquitoes collected from bovine baits, while it was only 5% from human baits. Comparatively five times mosquitoes were collected from bovine baits than the human baits. *C. whitmorei* was
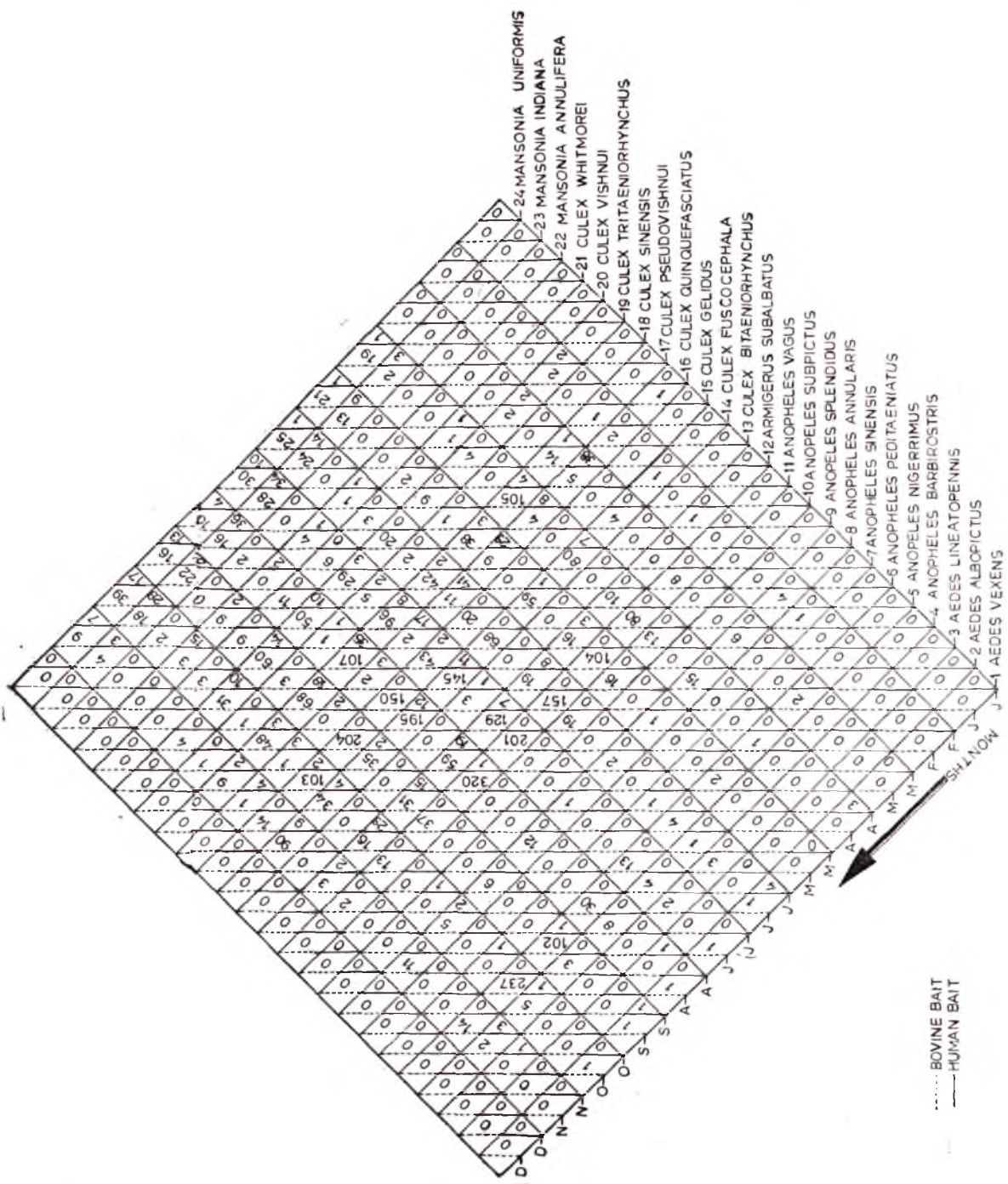
Fig. 2. Biting rate of mosquitoes during evening (dusk) over human and bovine bait.

species in their bait collections during August–October was noted to be earlier i. e., in June—August in present study area. This shift of the duration is probably due to early start of the rain.

M. indiana was about 24% of the the total mosquitoes received from human bait, while it was only 3% over bovine baits. About 1.25 times mosquitoes were collected from human baits than the mosquitoes from bovine baits. *M. uniformis* was found to be about 9% of the total over human baits and 4% over the bovine baits. The mosquitoes obtained over bovine baits were about 3 times the number received from human baits.

A. barbirostris, *A. annularis*, *A. subpictus*, *C. gelidus* and *C. vishnui* were mostly collected from bovine baits.

DISCUSSION

With the present study a total of 773 mosquitoes belonging to 6 genera and 26 species were collected from human baits, while a total 4,015 mosquitoes belonging to 5 genera and 24 species were collected from bovine baits from the state. The species recorded from human baits is of considerable importance because of the important vectors viz., *Mansonoides*, *C. quinquefasciatus* (vectors of filaria); *C. pseudovishnui* and *C. tritaeniorhynchus* (vectors of Japanese encephalitis) were recorded in considerable numbers.

From the observations it is clear that the culicine species were more over human baits, while the number of Anophelines over bovine baits were important component of the species obtained from bovine baits.

The monthwise numbers of mosquitoes landing for biting the human and bovine baits indicates the population pattern of the dusk biters to be unimodal

(i. e. showing single peak in the year) for *A. barbirostris*, *A. nigerrimus*, *A. subpictus*, *A. vagus*, *Ar. subalbatus*, *C. gelidus*, *C. tritaeniorhynchus*, *C. vishnui*, and *C. whitmorei*. The population of *C. preudovishnui*, *C. sinensis*, *M. uniformis* and *M. indiana* were found bimodal (i. e. showing two two peaks in a year). and *A. annularis* and *C. fuscocephala*, which are similar in their host preference, were also found similar in their trimodal (i. e. three peaks in a year) population pattern. The population of *Culex quinquefasciatus* were found feeding during the whole year, except during December. The population were noted to be arhythmic but higher during warmer months,

The present observations during dusk-biting regarding host preference, seasonal-changes in the biting, and early biting for *A. barbirostris*, *A. nigerrimus*, *A jeyporiensis* var. *candidiensis*, *A. maculatus* and its varity *willmorei*, *A. subpictus* and *A. vagus* are in conformity with the findings of CHIRSTOPHERS (1933), ASLAMKHANN (1976, 1978), and RAO (1984).

REISEN & ASLAMKHAN (1978) in their biting collections reported the complete disappearance of *A. subpictus* after November onwards due to flooding of the breeding habitats. Similarly the species disappearene during June onwards in the present study area are due to early rain. *A. splendidus* reported to be primarily cattle feeder by RAO (1984), was collected from the human–bait.

The present observation regarding the host preference of *Aedes vexens* is contradictory to the findings of TEMPELIS (1970) from Hawaian Island. The host preference and feeding, shortly after sunset of *Ae. lineatopennis* is in good agreement with the observations of REISEN & ASLAMKHAN (1978) but presence of the

aaout 3.5% of the total mosquitoes from human baits while it was only about 0.4% over bovine baits. About equal number of mosquitoes were received over human and bovine baits,

The observations during the present investigation in respect of dusk biting from human and bovine baits for *C. bitaeniorhynchus, C. fuscocephala, C. geligus, C. quinquefasciatus, C. pseudovishnui, C. tritaeniorhynchus,* and *C. vishnui* are in agreement with the findings reported by SIRIVANAKARN (1976).

M. annulifera was collected from bovine baits only, while the *M. indiana* and *M. uniformis* were collected from both the baits. The prevalence of *M. uniformis* during different moths differes from the earliar findings of REISEN & ASLAMKHAN (1978) from Pakistan. This shift of prevalence during different months in the study, are due to the change of physiography and behavioural aspects.

The absence of the most of the species during the month of January and December is probably due to being the coldest month of the year.

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BRIEF COMMUNICATION

MULTIRESISTANCE TO INSECTICIDES IN THE FIELD STRAIN OF *TRIBOLIUM CASTANEUM* HERBST (COLEOPTERA : TENEBRIONIDAE)

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Resistance in insects to insecticides has become a worldwide problem in agriculture and public health. Georghiou (1981) reviewed resistance to different insecticides in 432 arthropods of economic importance in the world. Champ & Dyte (1977) in their report on the 'FAO global survey for resistance in agricultural insects' recorded resistance to a number of inse_cticides in red-flour beetle, *Tribolium castaneum.* Resistance to malathion in this species was reported first of all in a population collected from a cargo from India to England (Dyte & Blackman, 1970). Subsequently, resistance to malathion was reported from godowns in the urban areas of India (Bhatia *et al.*, 1971; Rajak *et al.* 1973). Kalra *et al.* (1975) however reported a number of strains resistant to HCH during their surveys of godowns and rural homes in the Punjab, but none was found resistant to malathion. Some of the strains, however, were found tolerant to DDT.

Four strains of *T castaneum* of different origins were included in our studies on lindane resistance. Two of the strains called 'field strains' were compared with

the laboratory strain 'R', resistant to lindane and the standard susceptible strain 'S', imported from the Pest Infestation Control Laboratory, Slough (U K). Details of all the strains have been described (Barwal & Kalra, 1983). The field strain 'P', collected from Palampur, (H P) was as susceptible as the standard susceptible strain 'S', whereas the other field strain,
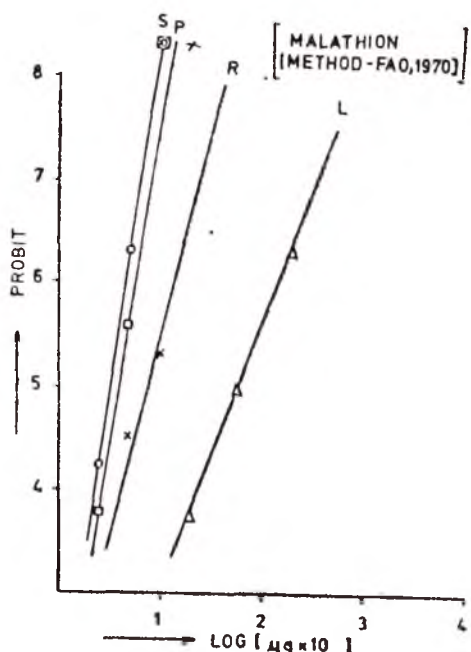

Fig. 1. Toxicity of malathion to lindane resistant and susceptible strains of *T. castaneum.*

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TABLE 1. Toxicity of malathion to different strains of *Tribolium castaneum*.

Strain	LC_{50} (% conc.)	Fiducial limits of LC_{50} at P = 0.05	Slope ± S E	Heterogeneity		Resistant ratio.
				chi square	D F	
S	0.031	0.026—0.036	5.93 ± 1.26	0.38	1	—
P	0.041	0.039—0.044	8.00 ± 1.55	0.38	1	1.34
L	0.564	0 425—0.750	2.425 ± 0.44	0.72	1	18.42
R	0.071	0 056—0.089	3.42 ± 1.08	0.59	1	2.33

originated from Ludhiana grain market, was 61.7 fold resistant to lindane as compared to > 180 fold resistance in the strain 'R' by topical application method. Further, strain 'L' was found to have developed 18.4 fold resistance to malathion according to the method described by the FAO (1970), whereas strain 'R' had 2.3 fold tolerance to this insecticide (Fig. 1; Table 1). It was considered to be the malathion specific resistance as it did not extend to fenitrothion and diehlorovos (BARWAL, 1977). Thus, strain 'L' was found to have developed multi-resistance to lindane and malathion under field condition.

During sixties, the practice of mixing DDT and HCH with grains in the rural and urban granaries was very common and malathion was recommended during seventies for spraying on stacks of bags containing food grains and walls of godown (BINDRA *et al.*, 1973). During seventies, use of HCH was restricted to insect pests in the premises of granaries. It was, therefore, indicated that strain 'L' was selected against HCH and malathion due to different mechanisms of resistanc for these two insecticides. Strain 'R' was reared in the laboratory and was selected for resistance to HCH, showing thereby cross resistance to the insecticides with

a common mechanism of resistance (BARWAL & KALRA, 1982). Strain 'P' was collected from a remote place in Palampur (H P), where use of insecticides was restricted to insect pests of public health. It was, therefore, as susceptible as the standard susceptible strain 'S'. Insects are being exposed to a number of insecticides in the field. However, stability of resistance to a particular insecticide depends on the nature of the mechanism of resistance and the degree of the selection pressure with that insecticide.

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AN OUTBREAK OF *SPODOPTERA EXIGUA* HUBNER (NOCTUIDAE : LEPIDOPTERA) ON TOMATO

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An outbreak of *Spodoptera exigua* incidence and large scale feeding was noticed on leaves, stems and fruits of tomato at Indian Institute of Horticultural Research, Hessaraghatta Farm, Bangalore, for the first time.

(Key words: Spodoptera exigua, tomato, new host record)

Spodoptera exigua, commonly known as beet armyworm, has been reported as a serious polyphagous pest on a variety of crops (NAIR, 1975; NAYAR *et al.*, 1976). During the course of our survey, we had noticed a serious outbreak of this cutworm both in the nursery as well as in the main transplanted crop of tomato, during the rabi season, 1986, in our biological control experimental field at Indian Institute of Horticultural Research, Hessaraghatta Farm, for the first time. The average population of the caterpillar per plant in the nursery was more than two. Further, the incidence was more while in the nursery stage than when compared to transplanted crop. In this note, a brief account of its biology and nature of damage with reference to tomato crop has been reported.

The caterpillars in their early stages scrape the leaves and in the later stages they not only completely defoliate the leaves but also bore into the stems and fruits. The eggs which are laid in clusters numbering about 50-60 are invariably covered with scales, and they are found to hatch within a period of 3-4 days. There are six larval instars, with a larval and pupal period of 15-16 and 6-7 days respectively.

Though *S. exigua* has been reported on a number of crops in India (NAIR, 1975; NAYAR *et al.*, 1976) and as a pest of tomato in Egypt (SHAHEEM, 1979) and in United States (ZALOM *et al.*, 1983), this is for the first time in India that we are reporting this pest in severe form on tomato in and around Hessaraghatta Farm, Bangalore, probably because of the favourable agro–climate of Bangalore and as well as by the introduction of the varieties like 'Punjab chora' wherein we have noticed more incidence of this pest when compared to 'Pusa ruby'. Further detailed studies on its biology and natural enemy complex are under progress.

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RECORD OF *ORTHEZIA INSIGNIS* BROWNE (HOMOPTERA : ORTHEZIIDAE) ON *PARTHENIUM HYSTEROPHORUS* LINNAEUS

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The insect *Orthezia insignis* (Homoptera : Ortheziidae) was found attacking heavily, the weed *Parthenium hysterophorus.*

(Key words : Orthezia insignis, Parthenium hysterophorus)

The congress weed, *Parthenium hysterophorus* Linnaeus, rapidly spread throughout the country following its first occurrence in Poona (Rao, 1956). The need to find a lasting solution to the problems posed by this noxious weed prompted many workers to search for biological control agents, especially insects. A large number of insects (Kumar *et al.*, 1979) and a few species of mites (Dagar & Singh, 1979) have been recorded on this weed in India.

A survey conducted during February, 1987, for the natural enemies of *Parthenium hysterophorus* in the forest area of University of Agricultural Sciences, G K V K, Bangalore, revealed a large number of *Parthenium* plants attacked by *Orthezia insignis* Browne. Plants, both young and old, were found densely colonised by the scale insect. Nymphs and adults were seen on all parts of the plant viz., main stem starting from the collar region, branches, leaves and peduncles. On leaves, the scale was confined to the lower surface and mostly present close to the main vein. Black sooty mould growth was seen on plants that were severely infested by the scale. When the infested

plants were uprooted and roots were examined, a few individuals were found feeding on the main root. In heavily infested plants drying of leaves was seen and the entire plant drooped due to the sap sucking activity of the insect. This scale insect which was earlier reported on citrus (Nair, 1975), coffee (Chacko *et al.*, 1977), *Jacaranda mimosaefolia* D. Don. (Siddappaji *et al.*, 1986) and *Chromolaena odorata* (L.) R. M. King & H. Robinson (Muniappan & Viraktamath, 1986) and hitherto found mainly on *Lantana camara* Linnaeus in this area, was observed for the first time on *Parthenium* and is a first record in India.

It was interesting to note that a few plants of *L. camara* in this area dried up completely following a build up of high populations of this scale recently. *Parthenium* plants that were present in the vicinity of *L. camara* were heavily attacked by the scale. Infestation was also found on plants growing in other spots away from *L. camara*. It is assumed that this insect, after being forced to leave *L. camara* following its drying up, must have accidentally encountered these plants and started

multiplying on them. Preliminary studies on artificial infestation in the glass house showed that the scale readily accepted *Parthenium* plants. Further investigations on the life history and alternate hosts of *O. insignis* are in progress.

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BRIEF COMMUNICATION

ALCIDES MORIO HELLER (CURCULIONIDAE : COLEOPTERA) CINNAMON FRUIT BORER

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Grubs of *Alcides morio* Heller were found feeding on the inner contents of cinnamon seeds. The extent of damage upto 60 per cent was recorded. Short descriptions of the weevil and its immature stages are also furnished.

(Key words: Cinnamon, *Alcides morio*, seed borer)

Cinnamon *(Cinnamomum verum)*, one of the major tree spices, is infested by many insect pests feeding on the foliage, shoots etc. They include the cinnamon butterfly *(Chilasa clytie)*, shoot and leaf webber *(Sorolopha archimedias)*, leaf miner *(Acrocercops* sp.), chafer beetle *(Popillia complanata)* and leaf beetle *(Singhala helleri)* (Singh *et al.*, 1978). During a survey for pests of cinnamon a grub tunnelling into the cinnamon seeds was observed in some plantations. In severe cases of infestation about 60% of the seeds were found damaged. The damage is of considerable economic importance since cinnamon is propagated mainly through seeds. The insect was got identified by the Commonwealth Institute of Entomology, London as *Alcides morio* Heller. The infested seed has a brownish spot on the seed coat with the extrusion of faecal matter. The seeds when split open show the presence of grub or pupa inside. The grub feeds voraciously on the inner contents of the seed, leaving a hollow berry ultimately.

Mature grub has a brownish head capsule with a milky white body which is 'U' shaped. It is mostly inactive. The grub attains a maximum length of 8–10 mm.

The pupation takes place inside the seed in brownish silken thread mass spun by the grub itself. The pupal period lasts 7–9 days. The milky white pupa turns brownish before the emergence of the weevil. The weevil cuts a circular hole on the seed coat and emerges through the hole. The weevil is dirty black in colour with a long snout. The females are larger than males. The average adult measurements of male and female are 8.0×3.5 mm and 10.0 × 4 0 mm, respectively. The adult weevil is not active.

The defence reaction of the weevil is to feign death by dropping when disturbed, retracting its appendages and remaining motionless. The adults were not found feeding even when seeds as well as leaves were provided. The longevity of the beetle is 5–7 days.

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BRIEF COMMUNICATION

THE BIOLOGY OF *APANTELES CREATONOTI* VIERECK (HYMENOPTERA : BRACONIDAE), A LARVAL PARASITOID OF *THIOCIDAS POSTICA* WLK. (LEPIDOPTERA)

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Apanteles creatonoti Viereck, a larval parasitoid of *Thiocidas postica* Wlk., a pest on ber tree was studied under laboratory conditions (24 $\pm$ 1°C, 55-60% R H). The eggs are white and hymenopteriform. Eclosion occurs 3 days after oviposition. There are 3 instars. The first two are vesiculate and last hymenopteriform. Matured parasitoid larvae emerged from the host, killing it and then spun a silver-white cylindrical cocoon. The total developmental time from egg to adult was 14-15 days. Egg stage 3 days, larval stage 6-7 days and pupal stage 5 days. Pupa exerate type. Adult lives for 12-13 days with 100% honey. Mating took place soon after emergence. Second instars of the host are preferred for parasitism.

(Key words: Apanteles creatonoti, parasitoid, biology)*

Biology forms basic information for the workers involved in biological control programmes for formulating mass rearing. The genus *Apanteles* is the largest biological control agent. Keeping this in view the present work was carried out.

50 early second instar larvae of *Thiocidas* were exposed to five mated females of *Apanteles*. Parasitoid eggs and larvae were collected after 12 h interval by dissecting parasitized host larvae in saline. The instars were identified by observing size of the head capsule and mandibles (Short, 1952, 1953).

Egg: The newly deposited eggs are white, thin walled and typically hymenopteriform. Eclosion occurs 3 days after oviposition.

Instars: The parasitoid has 3 instars, first two vesiculate and last hymenopteriform.

First instar: The first instar has a translucent body consisting of a broad quadrate head, 3 thoracic and 7 abdominal segments and a caudal vesicle. After 3 days, the body becomes more opaque and the head narrower. The first instar lasts 3 days.

Second instar: The body is cylindrical, straight and white. The larva consists of 13 well defined segments and a prominent vesicle. No spiracles could be seen. The second instar lasts 3 days.

Third instar: The larva tapers slightly towards both ends. Early last instar has an anal vesicle but it is absent in mature form. Mature parasitoid larvae emerged from the host, killing it and then spun a silvery cocoon. The third instar lasts 2 days.

Cocoon: After emergence, the last instar of the parasitoid, form densely

spun, cylindrical, silvery cocoon which is rounded at both ends.

Pupa: The pupa is exarate or free-type. It is light yellow initially except for the blackish eyes and the brown ocelli. The light yellow colour remains throughout the pupal period. The pupal stage lasts 5 days.

Adults: Adults are black in colour and live for 12–13 days with 100% honey solution, 3 days with water and 2 days without food. Mating took place soon after emergence. Early second instars of the host are mostly preferred for parasitization.

BROODRYK (1969) observed 3 instars in *Chelonus (Microchelonus) curvimaculatus* Cameron. The first occupies the greatest part of the larval life and the other two instars lasts a relatively short period. In the present species first and second instars require more time (3 days). In *Pseudoapanteles (Apanteles) dignu*s Muesebeck, the total developmental period from egg to adult was 18 days (CARDONA & OATMAN, 1971). In *C. diurnii* the total developmental time from egg to adult was about 18 days SATHE, 1986) while the present parasitoid

under laboratory conditions (24 ± 1°C' 55–60% R H) completes its development in 14–15 days.

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BRIEF COMMUNICATION

RECORD OF THE RED SPIDER MITE *TETRANYCHUS LUDENI* ZACHER (ACARINA : TETRANYCHIDAE) ON THE COCONUT PALM[1]

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Tetranychus ludeni was newly recorded from cocount plam foliage. The egg to adult period was completed in 8-11 days. January—February is the peak period of mite abundance in the field.

(Key words: Tetranychus ludeni, cocount)

GHAI & WADHI (1983) listed 17 species of phytophagous mites on the coconut plam *(Cocos nucifera* L.), including seven species of eriophyid, eight species of tetranychid and two species of tenuipalpid mites. SATHIAMMA (1985, 1987) added *Dolichotetranychus vandergooti* (Oudemans) (Tenuipalpidae); *Oligonychus iseilemae* (Hirst) and *Tetranychus* sp. (Tetranychidae) to this list. The third species was subsequently identified as *T. ludeni* Zacher. This is the first record of the species on a perennial crop like the coconut palm.

Colonies of *T. ludeni* inhabit the adaxial surface of the coconut leaflets, in profuse webbing and drain the sap ultimately to cause drying of the affected parts. PRITCHARD & BAKER (1955) distinguished the species by the presence of aedeagus bearing a very small distal knob without any posterior angulation.

In the laboratory, the egg to adult stages are completed in 8–11 days with a male to female ratio of 1:3. The females are longer–lived (6–27 days) as compared to the males (3–14 days). The fecundity varies from 6–13 eggs per female during the oviposition period of 5–9 days.

The peak period of population abundance in the field was during January and February and the mite was totally absent during June and July.

T. ludeni was first recorded as a greenhouse crop pest by ZACHER (1913) in France. Subsequently, a number of authors observed its occurrence on many vegetable crops. PUTTASWAMY & CHANNABASAVANNA (1979) reported 18 host plants of this mite including 13 new records from Karnataka. SADANA (1985) listed 26 host plants of *T. ludeni* from India. KARUPAUCHAMY & MOHANASUNDARAM (1987) observed this species on five host plants in Tamil Nadu. Beans is the only recorded host plant of this mite from Kerala (SARADAMMA & NAIR, 1976).

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BRIEF COMMUNICATION

OVICIDAL AND LARVICIDAL EFFECTS OF MOULT INHIBITOR (BAY SIR 8514) ON *SPODOPTERA LITURA* F

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One day old eggs were more susceptible than four day old eggs. Maximum inhibition was recorded at 100 ppm and above. Early instars were more susceptible than later instars. Complete mortality of second, third and fourth instar larvae was achieved at 100 ppm and fifth instar at 500 ppm. Inhibition concentration (IC_{30}) for eggs and effective concentration (EC_{50}) for larvae were also worked out.

(Key words: BAY SIR 8514, *Spodoptera litura*, ovicidal, larvicidal)

Moult inhibitors are gaining significance in Integrated Pest Management for their selectiveness, sparing natural enemies and favourable toxicological properties. A promising moult inhibitor, BAY SIR 8514 6.5 EC (Alsystin) was studied for its effect on eggs and larvae of *Spodoptera litura* F. The effects of moult inhibitor on egg and larva were inhibition of eclosion and moulting respectively.

Naked eggs dipped in different concentrations (0.25–500) ppm of BAY SIR 8514 resulted in 14.5 to 100 per cent inhibition of eclosion. Maximum inhibition was recorded at 100 ppm and above. One day old egg was more susceptible than four day old ones. The ovicidal effect of the moult inhibitor on *Spodoptera lituralis* Bo'sd (ASCHER, 1979) and *Laphygma frugiperda* S. a. A. (HAMMANN & SIRRENBERG, 1980) was reported earlier. The inhibition of eclosion of eggs deposited on BAY SIR 8514 treated leaves varied with concentrations. The effect was nil at 1 and 5 ppm, which increased gradually at

10 ppm and reached 100 per cent at 500 ppm. Simlar effects were reported on *L. frugiperda* (HAMMANN & SIRRENBERG, 1980) and *Graphognathus leucalamma* Buchman, *G. peregrinnus* Bohenan (HENZELL *et al.*, 1977). The inability of eggs to eclose might be due to the interference of deposition of cuticle. Dipping naked eggs might have had more surface area contact with insecticides than in the case of eggs laid on treated leaves which could be the reason for inhibition of eclosion in the former case even at very low concentrations.

The effect of chemical on the mortality differed as the age of larvae advanced. Early instars were more susceptible than later instars. Complete mortality of second, third and fourth instar larvae was achieved at 100 ppm and for fifth instar at 500 ppm. However highest concentration (500 ppm) could effect only 95 per cent mortality. HAMMANN & SIRRENBERG (1980) reported the larvicidal effect of the moult inhibitor on *Plutella maculipennis* Curtis and *L. frugiperda*.

TABLE 1. IC_{50} and EC_{50} value of BAY SIR for egg and larval stage of *S. litura*.

Stage	b value	IC/EC$_{50}$ (ppm)	Chi^2	fiducial limit (ppm)	
				Lower	Upper
Egg (age)					
One day	0.97	5.012	51.58*	2.917	8.610
Four day	0.85	7.590	21.87*	5.350	10.520
On treated leaves	2.02	44.670	85.67*	22.630	80.350
Larva (instar)					
Second	0.84	2.754	7.43	1.742	4.355
Third	0.79	5.140	5.95	2.523	8.279
Fourth	0.91	7.413	2.70	4.586	11.480
Fifth	1.03	20.420	1.47	13.610	30.630
Sixth	0.98	27.540	8.82	16.490	46.010

*heterogenous

IC_{50} (Inhibition Concentration for eggs) and EC_{50} (Effective Concentration for larvae) were worked out and given in the Table. IC_{50} for eggs laid on treated leaves was higher than other stages tested. EC_{50} for larvae increased gradually from second instar (2.754 ppm) to fourth instar (7.413 ppm) and showed sudden increase for fifth (20.420 ppm) and sixth (27.540 ppm) instar.

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OBITUARY

N. RAMACHANDRA PRABHOO
25.2.1937 — 17.6.1988

Professor N. R. Prabhoo passed away while at Changanacherry, Kerala State, on Friday 17.6.1988 at noon, due to cardiac arrest. He was hospitalised on feeling uneasiness, but all medical help was of no use. He leaves behind his young wife Dr. Mrs. Lalitha R. Prabhoo, who is a Linguistics Scholar, and two sons, Venugopal (20) and Balagopal (18), both students. The news was shocking to his friends, relatives as well as to his well-wishers, as he was apparently in perfect health and very active, radiating hope of assurance of a long and continued fruitful career for years to come.

N. Ramachandra Prabhoo was born in a middle class family on 25th February 1937 in Puthen Madom at Alleppey, to Mr. M. Narayana Prabhoo and Mrs. Saraswathi Prabhoo, in Kerala State. He has four brothers and four sisters. After early education in Alleppey, he took his M. Sc. from University of Kerala in 1958

studying in University College, Trivandrum. Subsequently, he joined Professor K. K. Nayar for his research and worked as Research Assistant, Research Officer, Senior Research Fellow and Research Associate in various projects, concentrating mostly on soil micro-organisms, especially on Collembola in which field he soon became one of the authorities. He got his Ph. D. in 1968 from University of Kerala. Especially during this early period of his research career he undertook tedious and strenuous journeys often by foot deep into the Western Ghats, when he appears to have developed his keen interest in field work and love to forerts.

He joined University of Kerala as Lecturer in Zoology in 1968 and became Reader in 1977 and Professor in 1984 in which capacity he has been working since then. As a result of his academic activities he left indelible impression on the Department.

His research interests were highly varied, including taxonomy (especially of micro-arthropods, nematodes and oligochaetes), ecology, soil zoology, environmental biology and population dynamics etc. He had profound knowledge in these and related fields. He worked out a number of research projects funded by different agencies and was recepient of Commonwealth Academic Exchange Fellowship in which capacity he visited Ife University (Nigeria) in 1984. He attended the II International Seminar on Apterygota in University of Siena, Italy in 1986 and also visited Laboratoire D'ecologie Generale Museum National D'histoire Naturelle, Brunoy, France. He participated in many national symposia at which he presented papers and/or presided over various scientific sessions or gave talks. He successfully guided a number of M. Phil. students; four research students took Ph. D. under his guidance and two have submitted their theses and are awaiting result. He has published about 60 papers in various fields in national and international journals. He was on the Boards of Studies of University of Kerala and of Calicut; he was also a Member of the Faculty of Sciences of University of Kerala for some time, and was actively involved in a number of other academic activities. He convened the III Oriental Entomology Symposium in 1984 and was one of the Founder (Life) Members of the Association for Advancement of Entomology and one of its Vice-Presidents for a long time. He was elected Vice-President of Association for the study of Soil Biology and Ecology in India (Bangalore) and was a Member of the Association for the study of Oriental Insects, and Member, Aphidological Society of India, Calcutta. He was a Member of the Editorial Board of *Entomon* from its inception and played crucial role in shaping the destinies of the Association for Advancement of Entomology and *Entomon*, both of which owe him a great deal. He was especially responsible for its ecoogy and systematics sections and was always freely avaiable for editorial advice whenever needed. Dr. Prabhoo was also on the Editorial Boards of *Oriental Insects* (Delhi), and of *Journal* of *Soil Biology and Ecology* (Bangalore). He was associated with writing a post-graduate level reference and text book on bio-ecology of soil invertebrates entitled "Biology of Soil Invertebrates" co-auhored with Dr. T. N. Ananthakrishnan, one of his closest associates. He has also written a book-let on animal systematics prepared for high school teachers, which was published by the Kerala State Institute of Science.

Dr. N. R. Prabhoo possessed a wide circle of friends and had an untiring, sincere, warm and pleasing personality: he was always helpful and understanding and at the same time forthright and open-minded. His life style was simple and one of dedication—be it for science or for personal values he cherished, or for service to society. He was also an active worker of the Kerala University Teachrs Association. He found time to carry out all these activities in the midst of much work; he was often the earliest to come to the laboratory and last to leave it. He also mingled easily and freely with children and often organised their activities. He was a music lover too. India and the world has lost an eminent scientist and a man. May his soul rest in peace.

V. K. K. PRABHU

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